Duke Energy Carolinas Smart $aver® Prescriptive Incentive Program

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Evaluation, Measurement, & Verification Report

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Executive Summary

Duke Energy Carolinas (DEC) engaged Cadmus to perform an impact evaluation of the Smart $aver® Prescriptive Incentive Program (Prescriptive Program).

Cadmus performed engineering desk reviews on the work papers describing deemed energy and demand saving calculation methodologies for a sample of measures. We adjusted the per-unit energy and demand saving estimates, as necessary, and applied the updated values to all participants in each reviewed measure for the evaluation period. Finally, we calculated a lighting and non-lighting net-to-gross (NTG) ratio based on the results of process evaluation surveys and calculated net energy and demand saving estimates for the measures reviewed.

This evaluation period was January 2013 through July 2015. We included applications in this evaluation period according to the date on which DEC paid the incentive. Table 1 lists the measures reviewed as part of this evaluation.

Table 1. Summary of DEC Prescriptive Program Measures Reviewed

Measure Category	Evaluated Measure/Measure Group
Food Service	Electronically Commutated Motors (ECM) in Cooler, Freezer, and Display Cases
HVAC	Variable Frequency Drives (VFD) on HVAC Fans
	VFD on HVAC Pumps
Lighting	Linear Fluorescent High Bay Replacing High-intensity Discharge (HID) Fixtures
	High Performance Linear Fluorescents
	LED Lamps
	LED Downlights
Process	VFD on Process Pumps
	VSD on Air Compressors
Pump	High-Efficiency Pumps

Impact Evaluation Results

Table 2 shows the realization rate between the claimed and adjusted gross savings as well as the NTG ratio applied to the adjusted savings. Based on the desk review analysis of the ten measures sampled, Cadmus estimated realization rates ranging from 69% to 139%. We calculated an 86% NTG ratio for lighting measures and a 40% NTG ratio for non-lighting measures, resulting in a 78% NTG ratio for the program overall.

Cadmus' current impact evaluation covered only a selection of measures and the realization rates cannot be extrapolated to the entire Prescriptive Program. However, we selected the process evaluation survey sample from all measures in the program and categorized them based on whether they were lighting or non-lighting measures. Therefore, the calculated lighting and non-lighting NTG ratios are applicable to those respective measure categories.

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Table 2. Program Claimed, Adjusted, and Net Energy Impacts

Measure Category	Measure / Measure Group	Claimed Savings (kWh)	Realization Rate	Adjusted Gross Savings (kWh)	NTG	Net Savings (kWh)
Food Service	ECM Motors in Cooler, Freezer, and Display Cases	1,857,315	108%	2,013,547	40%	805,419
HVAC	VFDs on HVAC Fans	14,553,141	139%	20,236,854	40%	8,094,741
	VFDs on HVAC Pumps	5,480,481	69%	3,781,949	40%	1,512,779
Lighting	Linear Fluorescent High Bay	85,708,927	68%	58,154,366	86%	50,012,755
	High Performance Linear Fluorescent	17,420,130	85%	14,767,697	86%	12,700,220
	LED Lamps	16,471,533	118%	19,376,927	86%	16,664,158
	LED Downlights	2,025,100	120%	2,430,118	86%	2,089,902
Process	VFDs on Process Pumps	674,734	106%	713,460	40%	285,384
	VSDs on Air Compressors	1,543,273	93%	1,435,649	40%	574,260
Pump	High-Efficiency Pumps	121,749	129%	157,638	40%	63,055

Table 3 and Table 4 show the claimed and adjusted summer coincident peak (CP), and non-coincident peak (NCP) demand savings for the measures included in this evaluation.

Table 3. Program Claimed, Adjusted, and Net Summer CP Demand Impacts

Measure Category	Measure / Measure Group	Claimed Summer CP Savings (kW)	Realization Rate	Adjusted Gross Summer CP Savings (kW)	NTG	Net Summer CP Savings (kW)
Food Service	ECM Motors in Cooler, Freezer, and Display Cases	246	96%	236	40%	94
HVAC	VFDs on HVAC Fans	2,188	141%	3,086	40%	1,234
	VFDs on HVAC Pumps	799	42%	333	40%	133
Lighting	Linear Fluorescent High Bay	13,758	90%	12,327	86%	10,601
	High Performance Linear Fluorescent	4,404	75%	3,324	86%	2,859
	LED Lamps	4,028	100%	4,009	86%	3,448
	LED Downlights	495	104%	517	86%	445
Process	VFDs on Process Pumps	183	80%	147	40%	59
	VSDs on Air Compressors	371	62%	230	40%	92
Pump	High-Efficiency Pumps	26	123%	32	40%	13

Table 4. Program Claimed, Adjusted, and Net NCP Demand Impacts

Measure Category	Measure / Measure Group	Claimed NCP Savings (kW)	Realization Rate	Adjusted Gross NCP Savings (kW)	NTG	Net Summer NCP Savings (kW)
Food Service	ECM Motors in Cooler, Freezer, and Display Cases	220	107%	236	40%	94
HVAC	VFDs on HVAC Fans	1,695	136%	2,310	40%	924
	VFDs on HVAC Pumps	603	72%	432	40%	173
Lighting	Linear Fluorescent High Bay	14,570	89%	12,976	86%	11,159
	High Performance Linear Fluorescent	3,568	71%	2,526	86%	2,173
	LED Lamps	4,476	116%	5,206	86%	4,477
	LED Downlights	550	122%	671	86%	577
Process	VFDs on Process Pumps	183	80%	147	40%	59
	VSDs on Air Compressors	371	62%	230	40%	92
Pump	High-Efficiency Pumps	33	123%	41	40%	16

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Table 5 provides the number of units per measure and the net energy and demand savings for each in the specified evaluation period.

Table 5. Per Unit Net Energy and NCP Demand Savings

Measure Category	Measure / Measure Group	Unit Count	Unit	NTG	Annual Adjusted Net Energy Savings Per Unit (KWh)	Adjusted Net NCP Demand Savings Per Unit (kW)
Food Service	ECM Motors in Cooler, Freezer, and Display Cases*	2,448	Per Motor	40%	329	0.04
HVAC	VFDs on HVAC Fans	10,592	Per Motor hp (horsepower)	40%	764	0.09
	VFDs on HVAC Pumps	1,976	Per Motor hp	40%	766	0.09
Lighting	Linear Fluorescent High Bay*	56,286	Per Fixture	86%	413	0.09
	High Performance Linear Fluorescent*	177,150	Per Fixture	86%	33	0.01
	LED Lamps	130,091	Per Fixture	86%	60	0.02
	LED Downlights	10,383	Per Fixture	86%	94	0.03
Process	VFDs on Process Pumps	705	Per Pump hp	40%	405	0.08
	VSDs on Air Compressors	2,595	Per Compressor hp	40%	221	0.04
Pump	High-Efficiency Pumps*	606	Per Pump hp	40%	104	0.03

* Savings are the average of the per-unit values provided in the work paper review section of the report.

Evaluation Parameters

The start and end dates for the review activities conducted for this impact evaluation were January 2013 to July 2015 for all measure groups.

Conclusions and Recommendations

Cadmus found the DEC Prescriptive Program work papers to be generally clear and well-documented. Cadmus made adjustments to work paper savings based on advancements in energy-efficient technologies, release of third-party field study results, and applicable codes and standards during the evaluation period.

Overall, Cadmus recommends that DEC perform verification on a representative sample of installed measures for an accurate *ex post* saving estimate in the next evaluation. Additionally, future program tracking may be improved significantly by tracking measure saving parameters (such as hp rating of motors) consistently, as well as by removing measure descriptions with generic base cases (when savings should be distinguished by base case). Detailed recommendations for future program tracking by measure is provided below.

Conclusion 1. For the ECM motors measure group, the size of the motors being replaced vary greatly; there is up to five times difference between the hp rating of the smallest and largest motors. The actual savings for a group of motors will vary widely based on the proportion of various sizes in the tracking database population.

Recommendation 1. Calculate refrigeration ECM motor savings on a per hp basis rather than a per motor basis.

Conclusion 2. For the VFDs on HVAC pumps measure, a recently completed metering study for Northeast Energy Efficiency Partnerships (NEEP) showed that there is a large variation in the amount of savings depending on what type of HVAC pump the VFD is installed on. For a VFD installed on a cooling water pump, a hot water pump, or a water source heat pump (WSHP) circulation pump, the typical savings ranged from 19% below to 34% above the average savings for all HVAC pumps.

Recommendation 2. Calculate the savings associated with the VFDs on HVAC pumps based on the pump's duty (cooling water versus hot water versus WSHP) as opposed to a general HVAC assumption.

Conclusion 3. Due to the great variability in pump sizing and configuration, Cadmus did not find an effective or accurate method to determine the average savings resulting from retrofitting an existing pump with a VFD, or to determine if an applicant's pump selection is an efficient choice through the Prescriptive program.

Recommendation 3. To accurately assess the savings potential of each application for the VFDs on process pumps or high-efficiency pump measures, administer incentives for these two measures through the Nonresidential Smart $aver Custom Program (Custom Program).

Conclusion 4. In the case of the VSD and VFD measures reviewed here, the savings depended on the quantity and the hp rating of the motors retrofitted. However, the hp rating of the motors were not always recorded or recorded accurately in the tracking database. Cadmus found this to be an issue in its review of the entire tracking database for measures whose total savings depended on not just the quantity of the measure but also additional parameters, such as hp rating of the motors.

Recommendation 4. Record the quantitative parameters for measure saving determination consistently to facilitate total measure savings and program saving calculations.

Conclusion 5. The tracking database includes three measure codes for VSDs on air compressors: one with a generic base case motor control scheme, one for load/unload controls, and one for variable displacement controls. The database does not include a measure code for the modulation base case control scheme identified in the work paper.

Recommendation 5. Discontinue the generic air compressor control scheme measure code and add a measure code for the modulation base case control scheme.

Introduction

Program Description

The Prescriptive Program is designed to influence business customer decisions to save energy by providing incentives to install qualifying high-efficiency measures such as lighting, HVAC, and motors. Duke Energy's commercial and industrial customers fund all energy-efficiency programs by paying an energy-efficiency rider based upon their kWh usage.

In the Prescriptive Program, customers may install selected energy-efficient measures and then submit an application for rebates. Customers must apply for the incentive within 90 days of installing the equipment and provide invoices with model numbers as proof of purchase. The Prescriptive Program is offered in conjunction with the Custom Program, which is being evaluated in a separate study. Energy-efficiency measures that are not part of the Prescriptive Program may still qualify for an incentive through the Custom Program. The measures offered through the Prescriptive Program have pre-calculated deemed energy savings, while the measures eligible for the Custom Program require customers to submit project-specific energy savings calculations with each application. The combination of both programs provides Duke Energy business customers with a flexible range of options to meet their individual needs for energy-efficient equipment.

DEC completed its last evaluation of the Prescriptive Program in 2013. This evaluation covered the high performance linear fluorescent and occupancy sensor measures and relied on verification of a sample of these measures installed.[1]

The biggest program changes from year to year have been the addition of new technologies to the list of qualifying prescriptive measures and the removal of technologies that have become common practice as a result of market transformation. In 2012, in response to the Energy Independence and Security Act (EISA) of 2007, Duke Energy ended incentives for replacing T12s with T5, Standard T8s, and High-Output T8s. In 2014, Duke Energy removed the chiller tune-up incentives from the program and added new information technology, LED lighting, HVAC, and food service measures to program. In 2016, Duke Energy removed server virtualization from the list of IT measures.

[1] TecMarket Works. *Process and Impact Evaluation of the Non-Residential Smart $aver Prescriptive Program in the Carolina System: Lighting and Occupancy Sensors*. Prepared for Duke Energy. April 5, 2013.

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Table 6 Evaluated Measure Participation (by Date Paid – 01/2013 to 07/2015)

Measure Category	Measure	Participant Application Count
Food Service	ECM Motors in Cooler, Freezer, and Display Cases	139
HVAC	VFDs on HVAC Fans	93
	VFDs on HVAC Pumps	18
Lighting	Fluorescent High Bay Fixtures	687
	High Performance Linear Fluorescent	1,085
	LED Lamps	893
	LED Downlights	142
Process	VFDs on Process Pumps	5
	VSDs on Air Compressors	27
Pump	High-Efficiency Pumps	10

Evaluation Objectives

The evaluation objective was to review DECs' claimed savings for high-impact Prescriptive Program measures. The evaluation did not perform verification on the installed measures.

Researchable Issues

The researchable issues are summarized here:

- Do the work paper saving calculation methodology, assumptions, and inputs need adjustment based on secondary data sources?
- Do the work paper saving calculation methodology, assumptions, and inputs need to be updated as a result of recent changes in codes and standards?
- What is the level of freeridership and spillover in the program participants?

Methodology

Overview of the Evaluation Approach

Study Methodology

Cadmus performed engineering desk reviews on DEC's work papers describing deemed energy and demand saving calculation methodologies. The work papers were prepared by Franklin Energy Services and are referred to in this document as FES work papers or work papers.

In evaluating DEC's Prescriptive Program, we performed the following activities:

- Selected measures with greatest impact on program savings during the evaluation period from each of the following measure categories: food service, HVAC, lighting, process, and pumps
- Performed a desk review of the work papers describing the measure saving calculation methodology, assumptions, inputs and per-unit savings
- Adjusted estimated energy, NCP demand, or CP demand savings, if necessary, for the selected measures
- Applied the adjusted per-unit saving values across all applicants for the measure reviewed
- Identified potential improvements to work paper for future program years

Duke Energy provided the tracking database containing the participant records for the evaluation period. We used the claimed savings for the population of participants to determine high-impact measures in each measure category. Duke Energy provided the work papers associated with each sampled measure.

Cadmus assessed the baseline and efficient equipment characteristic assumptions used in the work papers to estimate deemed savings for each measure evaluated. We referred to secondary sources that verified these inputs during the evaluation period, where available. If verified values were not available, we tested the assumptions against manufacturer data, national market assessment studies, and available TRMs.

Cadmus did not perform any verification of the quantity or characteristics of the measures installed that would require statistical sampling.

The work papers reviewed here calculate CP demand savings by making assumptions about the percentage of load during DEC peak periods.[2] Cadmus has reviewed these assumptions and provided any adjustments necessary. DEC may choose to use the adjusted work paper CP demand savings estimated in this report or those calculated based on DEC load profiles in their Demand Side Management Option Risk Evaluator (DSMore) software.

[2] DEC has identified its summer peak hour as 16:00 – 17:00 in July and winter peak hour as 7:00-8:00 in January.

Net-to-Gross Analysis

Cadmus calculated the applicable NTG ratio based on the results of participant surveys completed for DEC by TecMarket Works and Cadmus as part of the latest process evaluation of the Prescriptive Program.[3] TecMarket Works completed the first wave of surveys in October 2014 and Cadmus completed the second wave in October 2015.[4]

3 Cadmus. *Process Evaluation of the 2013-2014 Smart $aver Nonresidential Prescriptive Incentive Program in the Carolinas System.* Prepared for Duke Energy. April 15 2016.

4 Cadmus acquired TecMarket Works in March 2015.

Impact Evaluation Analysis

This section presents the results of the analysis performed for DEC's Prescriptive Program in preparation for the work paper reviews. We have organized our findings into the following sections:

- Program tracking data review and measure selection
- Net savings analysis

Program Tracking Data Review and Measure Selection

The program tracking database identified the claimed per-unit gross energy and demand saving values for each application to which an incentive was paid. The database did not include the total savings claimed as a result of each application.

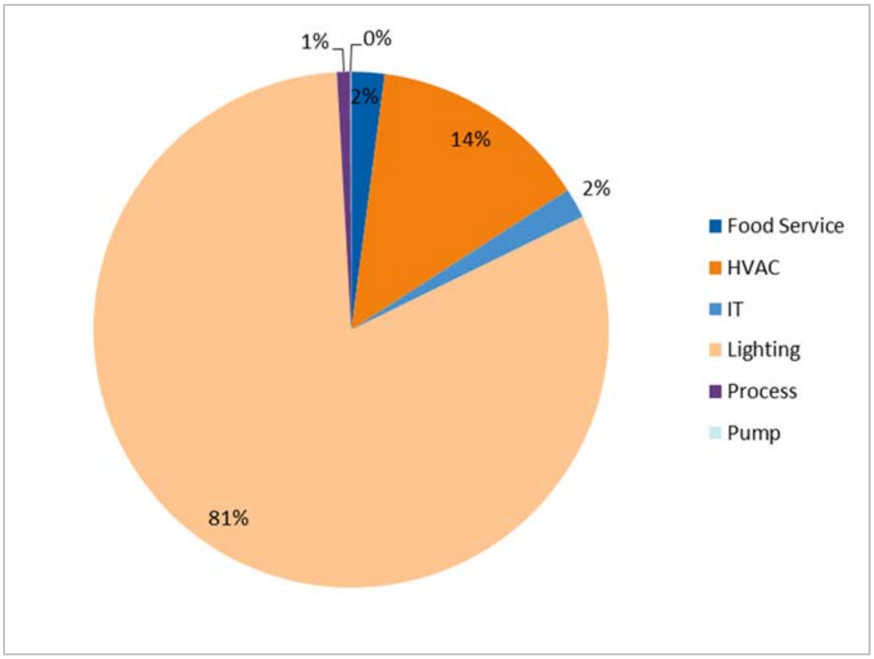
The total savings depend on the quantity of the measures installed. In most cases, the measure savings also depend on the total square foot, hp, or tonnage of the measure installed. These parameters are identified as *custom quantities* in DEC's tracking database. *Custom quantities* are not always recorded or recorded accurately in the database. Cadmus performed quality control on the *custom quantities* recorded and, where missing, we estimated values based on the incentive paid amounts. Cadmus then calculated total gross claimed savings for each application paid in the database, based on quantity, *custom quantity*, and the savings claimed per-unit. Table 7 lists the results.

Table 7. DEC Prescriptive Program Savings by Measure Category

Row Labels	Gross Energy Savings (%)	Gross Energy Savings (kWh)	Gross NCP (kW)	Gross CP (kW)
Food Service	2%	5,485,013	856	592
HVAC	14%	36,269,670	8,560	8,141
IT	2%	4,935,150	736	331
Lighting	81%	213,988,146	38,294	35,953
Process	1%	2,218,007	555	555
Pumps	0%	121,749	33	26
Total	**100%**	**263,017,736**	**49,033**	**45,598**

Cadmus' review of the tracking database revealed that the majority of the claimed savings are attributed to lighting and HVAC measures. The pumps measure category contributed the least to overall program savings. The program energy savings breakdown by measure category is shown in Figure 1.

Figure 1. DEC Prescriptive Program Energy Savings by Measure Category (n=263,017,736 kWh)

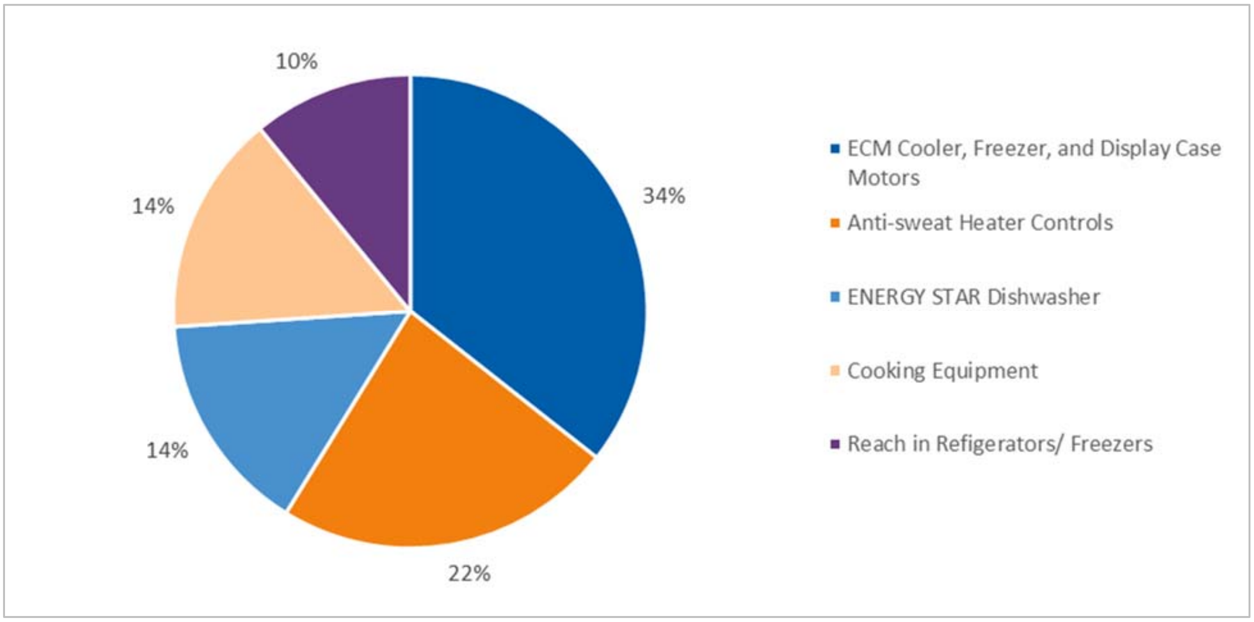


Cadmus reviewed the contribution of measures (or measure groups) to the savings under each measure category, and selected a set of high-impact measures for desk reviews. We selected measures from all categories, except for Information Technology (IT). The breakdown of measures under each measure category and the measures chosen for review are described in the following sections.

Food Service

Cadmus evaluated the ECM motors from the food service category for desk review. ECM motors contributed the majority (34%) of the savings. Figure 2 shows the breakdown of Food Service savings for measures contributing 10% or more total savings.

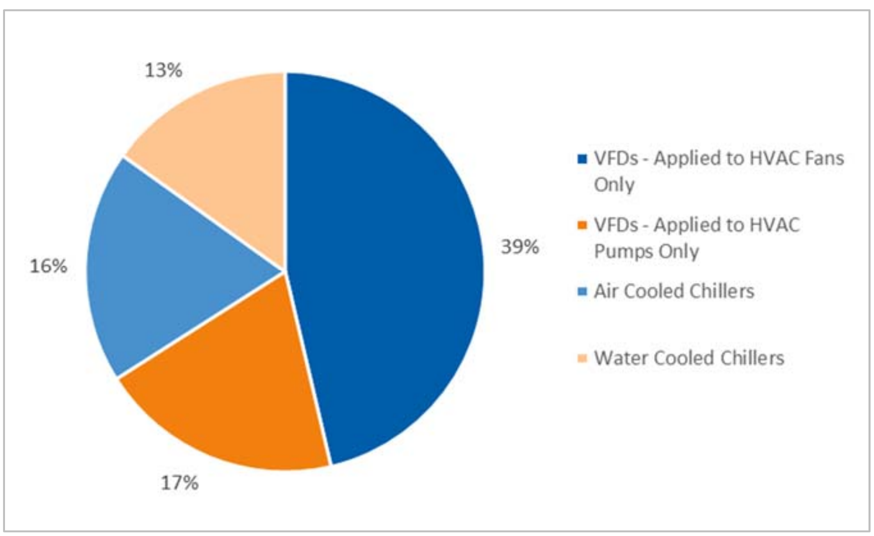
Figure 2. DEC Prescriptive Program Energy Savings: Food Service (n=5,485,013 kWh)



HVAC

For the HVAC category, we evaluated VFD measures applied to HVAC fans and pumps. Together these two measures contributed 56% to the measure category program savings. Figure 3 shows the breakdown of savings from HVAC measures that contributed 10% or more to total savings.

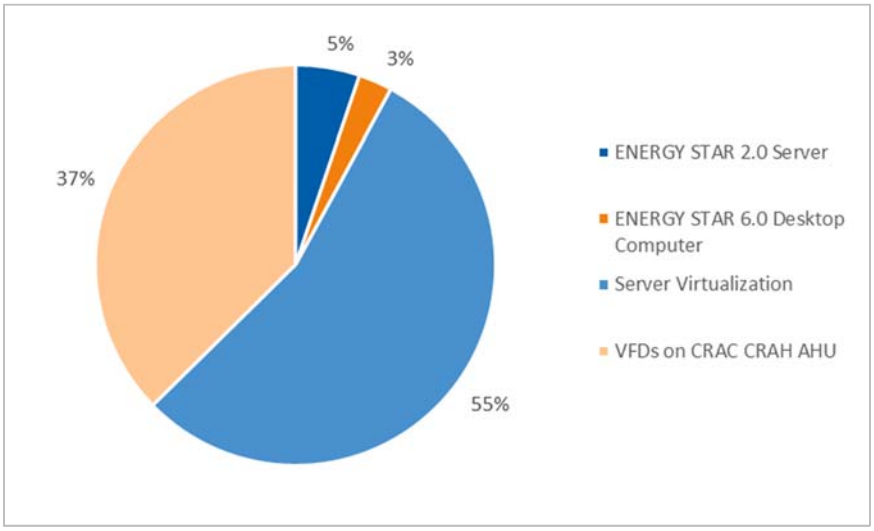
Figure 3. DEC Prescriptive Program Savings: HVAC (n=36,269,670 kWh)



Information Technology

Server virtualization contributed more than half of the savings in the IT measure category. Though initially selected for review, we removed it from sampled measures as DEC no longer provided rebates for this measure in 2016.

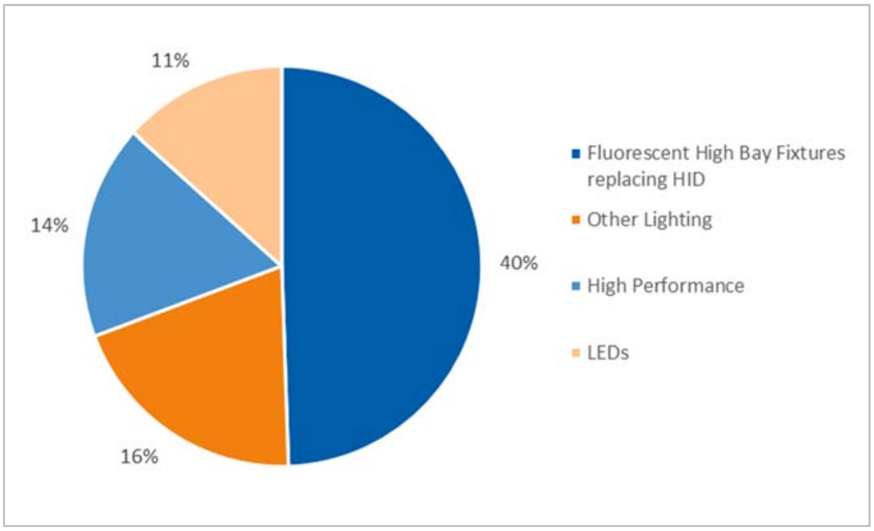
Figure 4. DEC Prescriptive Program Energy Savings: IT (n=4,935,150 kWh)



Lighting

Due to their large impact on program savings, the evaluation team chose the fluorescent high bay fixtures replacing HIDs, high performance linear fluorescent, and LEDs measure groups for the work paper review.

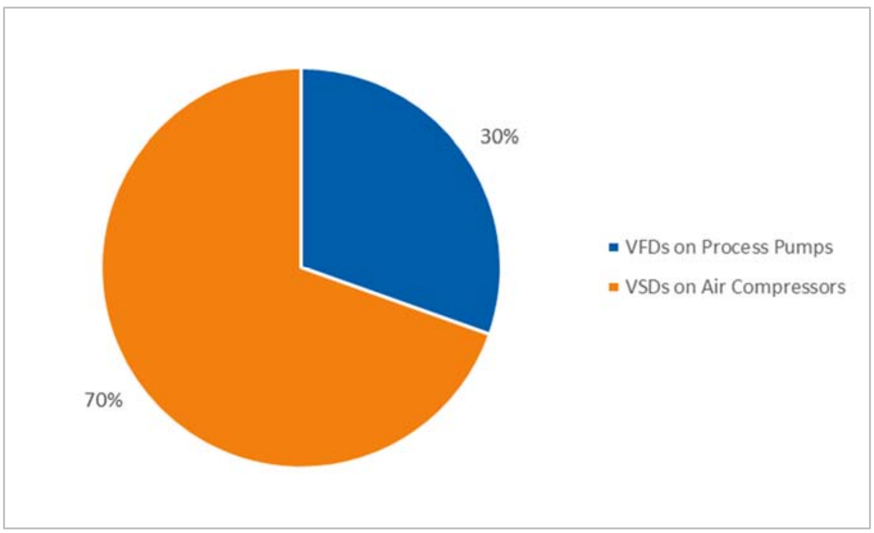
Figure 5. DEC Prescriptive Program Savings: Lighting (n=213,988,146 kWh)



Process Equipment

We reviewed all measures in the process measure category (Figure 6), which consisted of VFDs on process pumps and VSDs on air compressors.

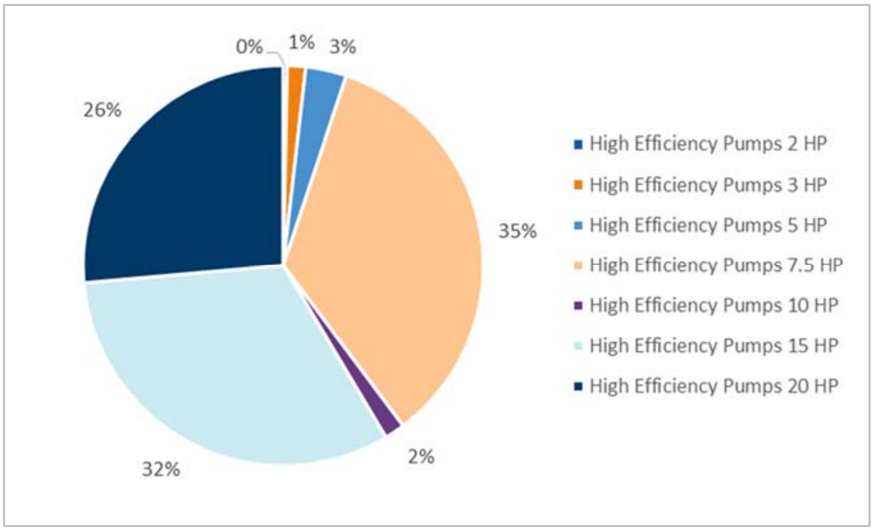
Figure 6. DEC Prescriptive Program Savings: Process Equipment (n=2,218,007 kWh)



Pumps

Figure 7 shows the breakdown of energy savings for the high-efficiency pump measure category. A single work paper describes the saving calculation methodology for all pumps measures; therefore, Cadmus included all pump measures in the review.

Figure 7. DEC Prescriptive Program Savings: Pumps (n=121,749 kWh)



Net Savings Analysis

Cadmus calculated the applicable NTG ratios based on the results of participant surveys completed by TecMarket Works and Cadmus as part of the latest process evaluation of the Prescriptive Program.[5] TecMarket Works completed the first wave of surveys in October 2014, and Cadmus completed the second wave in October 2015.

Freeridership Methodology

The evaluation team used two different sets of questions from the participant surveys. The team asked each participant both sets of questions and combined the results to estimate the level of energy impacts attributable to freeridership.

For the first set of questions, the team began the survey by asking participants if they would have purchased the same equipment without the program and when that purchase would have occurred. The team then asked respondents who said they would have delayed their purchase to estimate how long they would have delayed the purchase. Cadmus used the results from these two questions to establish a "gateway" freeridership score.

5 Cadmus. *Process Evaluation of the 2013-2014 Smart $aver Nonresidential Prescriptive Incentive Program in the Carolinas System.* Prepared for Duke Energy. April 15, 2016.

Specifically, the first question within the first set of questions asked survey respondents what their behavior would have been if the rebate had not been available. Respondents provided responses within the following categories:

- Bought the same new unit at the same time
- Bought the same new unit at a later time
- Bought a used unit at the same or a later time
- Continued to use the previously installed unit and did not purchase a new or used unit

As shown in Table 8, Cadmus assigned each surveyed participant a gateway freeridership score. For participants who indicated that they would have bought the same unit at the same time, we assigned a gateway freeridership score of 100%. For participants who said that they would have continued using the currently installed unit, we assigned a freeridership score of 0%. To estimate freeridership for participants who indicated that they would have bought their units at a later time, we asked an additional question to determine when they would have purchased the units in the absence of the program. For the purposes of establishing the gateway freeridership score, we treated used units the same as new units and captured differences in efficiency levels between new and used units in the second of a two-step process for calculating freeridership.

Table 8. Step One: Gateway Score Based on Timing of Replacement

Gateway Question Responses	Gateway Freeridership Score
Bought same new unit at the same time	100%
Bought same new unit within 6 months	75%
Bought same new unit 6 to 12 months later	50%
Bought same new unit 12 to 24 months later	25%
Bought same new unit more than 24 months later/delayed purchase indefinitely	0%
Bought same new unit but do not know when	Average % all responses in the five rows above
Bought used unit at the same or later time	Same percentages as new units above
Continued using old unit	0%
Do not know what organization would have done	Mean of all valid responses above

In the second step for calculating freeridership, Cadmus used responses from a second set of questions that asked participants what they would have done without the incentive, and what they would have done without the Prescriptive Program information and technical assistance.

Respondents provided responses in the following four categories:

- Bought a unit with at least the same efficiency level
- Bought a unit with a different efficiency level

- Would not have done the project
- Do not know what organization would have done

For participants who said that they would have bought the same efficiency level without the incentive or program information and assistance, we assigned a freeridership score equal to their gateway freeridership (Table 9). For participants who said they would have purchased less efficient units, we assigned freeridership scores equal to their gateway freeridership score multiplied by a discounting factor based on the relative level of efficiency compared to the unit they did purchase through the program. For participants who did not know what their organization would have done, we assigned a modifier to their gateway freeridership score based on the mean of responses from participants who answered the question.

Table 9. Step Two: Influence of Financial Incentive and Program Information/Technical Assistance

Response for "without financial incentive" and "without program information and technical assistance"	Modified Freeridership Score
Purchased a unit with the same level of efficiency as the new unit purchased through the program	Gateway freeridership X 100%
Different choice "almost as efficient as new model"	Gateway freeridership X 75%
Different choice "significantly more efficient than old model"	Gateway freeridership X 50%
Different choice "somewhat more efficient than old model"	Gateway freeridership X 25%
Different choice "efficiency similar to old model"	Gateway freeridership X 0%
Different choice "not sure what efficiency level"	Gateway freeridership X mean modifier of all other "different choice" responses
Would not have done this project	Gateway freeridership X 0%
Do not know what organization would have done	Mean of all valid responses above

Since the program includes both an incentive payment and technical assistance and program information, each of which can motivate a participant to purchase and install the more efficient choice, we scored the influence of the incentive on one path and the influence of the technical assistance or program information on another path. The final per-respondent freeridership estimate is the lower of their two freeridership scores resulting from these two paths.

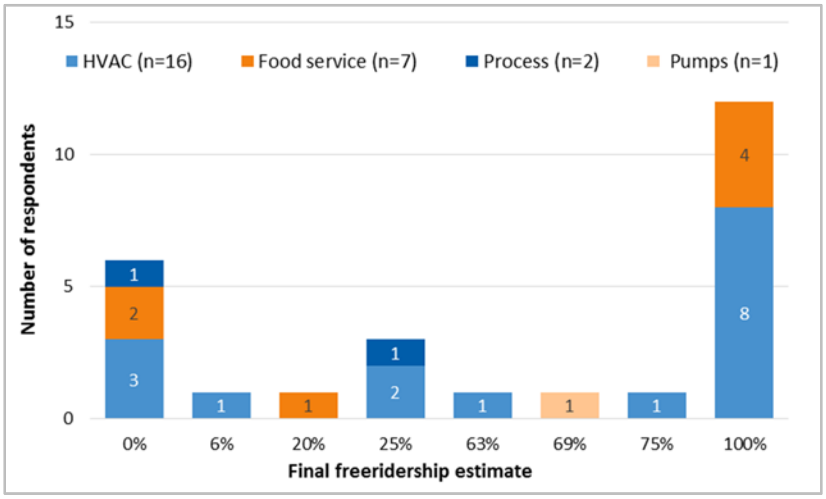
For the final step in calculating freeridership, Cadmus weighted the individual freeridership estimates for the surveyed participants by their claimed savings. We chose to use claimed savings for the weighting analysis, since the impact evaluation described in this report covered only select measures in the program and adjusted gross savings were not available for all survey respondents.

Freeridership Results

Non-lighting Participants

Figure 8 shows the distribution of final freeridership estimates for all 26 surveyed participants who answered the freeridership questions about non-lighting measures. The team assigned freeridership scores of 100% to about half (46%) of the surveyed participants, which indicates they are freeriders who did not contribute any savings to the program.

Figure 8. Distribution of Non-Lighting Freeridership Estimates for 26 Surveyed Participants



After weighting the respondents' freeridership scores by their organizations' gross claimed savings from their non-lighting projects, we calculated a savings weighted freeridership score of 60% for non-lighting measures. Thus, the estimated percentage of gross savings from non-lighting projects which are lost to freeridership is 60%. The following bullet list breaks down the freeridership results by measure category:

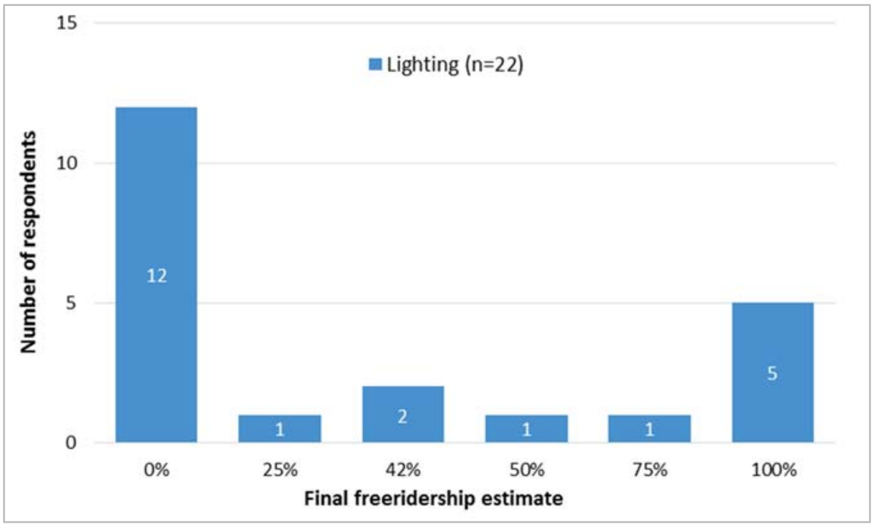
- For the 16 respondents who installed HVAC measures, the savings-weighted average freeridership is 63%.
- For the seven respondents who installed food service measures, we calculated 60% freeridership.
- For the two respondents who installed process measures, we calculated 13% freeridership.
- For the one respondent who installed pump measures, we calculated 69% freeridership.

Note that Cadmus provided the above non-lighting measure freeridership values for informational purposes only. Cadmus did not design the evaluation plan to achieve statistically significant estimates of freeridership at the measure level. The surveyed sample of non-lighting measures by category was further limited by the low levels of participation in those categories. The measure level freeridership values should not be used for program planning.

Lighting Participants

Figure 9 shows the distribution of freeridership estimates for 22 respondents. Cadmus calculated freeridership scores of 0% (no freeridership) to slightly more than half of surveyed lighting participants (55%). We assigned approximately a quarter of the surveyed lighting participants (23%) freeridership scores of 100%.

Figure 9. Distribution of Lighting Freeridership Estimates for 22 Surveyed Participants



After weighting the respondents' freeridership scores by their organizations' gross claimed savings from lighting projects, we calculated a savings weighted freeridership score of 14%.[6]

Spillover

The survey included questions to determine the extent to which the program's information and incentives motivated participants to take additional efficiency actions or install non-incented measures. We found very little evidence of spillover for this program.

Net to Gross Adjustment

The final step in calculating net to gross adjustments for this program is to calculate the NTG ratio for lighting and non-lighting measures.

Non-Lighting NTG

To estimate the net to gross adjustment for non-lighting measures, we compared the weighted average freeridership (60%) with negligible spillover. The average program-wide NTG ratio for this program is 40%, calculated as follows:

$$Non - lighting\ NTG = 100\% - Freeridership + Spillover = 100\% - \ 60\% + 0\% = 40\%$$

[6] Three of the 22 customers surveyed about lighting measures accounted for a combined 65% of the total savings, and all three were assigned freeridership scores of 0%.

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Lighting NTG

To estimate the NTG adjustment for lighting measures, we compared the weighted average freeridership (14%) with negligible spillover. The average program-wide NTG ratio for this program is 86%, calculated as follows:

$$Lighting\ NTG = 100\% - Freeridership + Spillover = 100\% - \ 14\% + 0\% = 86\%$$

Combined NTG

The combined NTG ratio for all measures in the program is 78%. It is calculated based on the lighting and non-lighting NTG ratios weighted by program savings:

$$Program\ level\ NTG = (86\% \text{ x } 81\%) + (40\% \text{ x } 19\%) = 78\%$$

The measure category and program-level NTG ratios only include adjustments for freeridership and short-term participant spillover. Cadmus did not estimate short- and long-term non-participant spillover or short- and long-term market effects as a part of this study.

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Work Paper Reviews

ECM Cooler, Freezer, and Display Case Motors

For the ECM cooler, freezer, and display case motor (ECM motor) measures, DEC applied a deemed savings per each motor replacing a low efficiency motor in commercial refrigeration applications. DEC incentivized 139 unique applications for this measure group, including 95 replacing permanent split capacitor (PSC) motors in walk-in coolers and freezers, 31 replacing shaded pole (SP) motors in walk-in coolers and freezers, and 44 replacing motors in display cases.

DEC used two different work papers to estimate the per-motor savings for these measures: one for ECM motors replacing PSC and SP motors in walk-in coolers and freezers and one for ECM motors replacing all motors in reach-in display cases.

Table 10 shows the deemed energy, NCP demand, and CP demand savings values in the work paper as well as the savings shown in the tracking database for the evaluation period.

Table 10 DEC Deemed Savings for ECM Motors

Replacement Type	Savings	Savings per Motor		
		Work Paper	Tracking Database	
			2013	2014-2015**
Replacing PSC in Cooler/Freezer*	Average NCP Demand (kW)	0.0660	0.2006	0.2006
	Summer CP Demand (kW)	0.0510	0.3296	0.1809
	Energy (kWh)	581	1,757	1,757
Replacing SP in Cooler/Freezer*	Average NCP Demand (kW)	0.2010	0.0663	0.0663
	Summer CP Demand (kW)	0.1810	0.1090	0.0590
	Energy (kWh)	1,757	581	581
Replacing Display Case Motor	Average NCP Demand (kW)	0.0456	0.0456	0.0456
	Summer CP Demand (kW)	0.0410	0.0668	0.0369
	Energy (kWh)	356	356	356

* Cadmus suspects that the savings figures were inverted between the PSC and SP motor replacement measures in the tracking database as they are exactly opposite of the work paper figures.

** The only difference between 2013 and 2014-2015 savings figures for cooler and freezer measures were summer CP demand savings. Cadmus could not find any documentation explaining this change.

Work Paper Methodology

Both work papers estimate the savings from the motors themselves as well as the savings from a reduced cooling load, as efficient motors produce less waste heat that must be removed by the refrigeration systems.

Walk-in Coolers and Freezers

In this FES work paper, per-motor savings were estimated based on a weighted average of savings calculated for replacing PSC and SP motors ranging from 1/40 hp to 1/2 hp.

The work paper estimated the motor savings by subtracting the ECM efficient case assumed input wattages (W) from the existing assumed values. The assumed input wattages range from 1,060 W/hp to 3,600 W/hp depending on the rated motor size and technology. The savings resulting from the reduced cooling load were then estimated based on assumed refrigeration system efficiencies which in turn were based on assumed coefficient of performance (COP) values of 2.5 and 1.3 for coolers and freezers, respectively.

The work paper does not cite a source for the assumed motor input wattages, the refrigeration system efficiencies, or the basis for weighting the savings associated with PSC and SP motor replacements and those associated with the various motor sizes.

The work paper assumes operating hour for motors in both coolers and freezer to be 8,760 and a peak demand CF of 0.9 based on the 2010 Wisconsin TRM. However, Cadmus could not find the CF value in the TRM.

Display Cases

In this work paper, per-motor savings are based on calculations found in the 2009 Ohio TRM. [7] The TRM assumes that the average SP motor input power, regardless of rated size, is 41.3W and the average ECM motor input power is 11.3 W. The TRM estimates the savings resulting from reduced refrigeration load by applying a bonus factor of 1.3 for coolers and 1.5 for freezers based on assumed and uncited refrigeration efficiencies. The TRM assumes operating hour for motors in both coolers and freezer to be 8,760 and duty cycles of 100% for coolers and 94% for freezers. The work paper assumes a CF = 0.9 and states that this is based on the 2010 Wisconsin TRM. However, Cadmus could not find the 0.9 value in the TRM.

Work Paper Methodology Adjustments Necessary

The motor input wattages used, for both the baseline and efficient cases, did not include sources and thus could not be verified. Cadmus updated the input wattages for the baseline SP motor cases and efficient ECM motor cases using data Cadmus collected as part of the commercial refrigeration load shape project performed on behalf of NEEP in 2012 - 2013.[8] This study included direct power measurement of a large sample of verified installations to determine an average input wattage normalized by motor hp rating. The average normalized input wattages found in this study were 2,088

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[7] The Public Utilities Commission of Ohio. Technical Reference Manual for Ohio Senate Bill 221 Energy Efficiency and Conservation Program and 09-512-GE-UNC. October 15, 2009.

[8] Cadmus. *Commercial Refrigeration Loadshape Project Final Report.* Prepared for Northeast Energy Efficiency Partnerships Regional Evaluation, Measurement, and Verification Forum. October 9, 2015.

W/hp and 758 W/hp for SP and ECM motors, respectively. The study did not have enough data to normalize input wattages of PSC motors so we used data included on vender specification sheets for PSC motors.[9]

Instead of using the refrigeration efficiencies of only a handful of display case models, Cadmus used values from the DOE2.2R refrigeration modeling software as the values are more representative of the wide range of coolers and freezer installations. We used an energy-efficiency ratio (EER) of 9.8 for coolers and 4.0 for freezers for both the walk-in and display case measures.

Given the lack of documentation or explanation for how FES weighted the savings between the various motor sizes, Cadmus weighted the estimated per-motor savings based on the proportions of the different motors sizes in the tracking database during the evaluation period.

Table 11 shows the proportions of the different motor replacements for the walk-in PSC measure. The population weighting used in the work paper for the walk-in PSC measure varied significantly from the distribution shown in the tracking database. The work paper assumes that only 20% of the PSC motor replacements are for 1/20 hp motors or smaller. However, as shown in Table 11, 85% of the PSC motor replacements were for 1/20 hp and 15% for 1/15 hp. This is the main factor contributing to the low realization rate for the walk-in PSC replacement measure as smaller motors receive less savings.

Table 11. Walk-in PSC Motor Replacements Weighting Distribution

Motor Size (hp)	Number of Motors	% of Total (Weighting Factor)
1/20	50	84.7%
1/15	9	15.3%
Total	**59***	**100.0%**

* Cadmus only used the applications that included clear hp ratings to determine the weighting.

Table 12 shows the proportions of the different motor replacements for the walk-in SP measure. The population weighting used in the work paper for the walk-in SP measure varied significantly from the distribution shown in the tracking database. For example, the work paper assumes that only 17% of SP motor replacements are for 1/20 hp motors. However, as shown in Table 12, nearly four times that fraction of SP motor replacements (63%) were for 1/20 hp motors.

9 Specification sheets are available online: https://www.grainger.com/product/DAYTON-1-20-hp-3RCX2?functionCode=P2IDP2PCP

Table 12 Walk-in SP Motor Replacements Weighting Distribution

Motor Size (hp)	Number of Motors	% of Total (Weighting Factor)
1/50	1	3.3%
1/20	19	63.3%
1/15	10	33.3%
Total	**30***	**100.0%**

* Cadmus only used the applications that included clear hp ratings to determine the weighting.

Table 13 shows the proportions of the different motor replacements for the display case motor replacement measure. For the display case measure, the adjusted savings are much greater than the work paper and tracked savings. This is mainly because the work paper figures assume that most motor replacements were for much smaller motors than what is shown in the tracking database. Because most replaced motors are much greater in size than the work paper assumptions, the adjusted savings are much greater.

Table 13. Display Case Motor Replacements Weighting Distribution

Motor Size (hp)	Number of Motors	% of Total (Weighting Factor)
1/50	5	25.0%
1/30	4	20.0%
1/20	5	25.0%
1/15	4	20.0%
1/10	2	10.0%
Total	**20***	**100.0%**

* Cadmus only used the applications that included clear hp ratings to determine the weighting.

Because the tracking database does not indicate whether the motors are in coolers or freezers, Cadmus estimated the average savings based on assumed equal distribution. We assumed a CF of 1.0 because it is highly likely that the refrigeration systems that these motors are a part of will have high cooling demand during peak grid demand periods.

Work Paper Adjustment Results

Table 14 shows the adjusted deemed savings in comparison with the program tracking values for the three ECM motor measures.

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Table 14. Adjusted ECM Motors Measure Savings

Measure	Savings	Work paper [A]	Adjusted [B]	Adjustment Factor [B/A]
ECM Replacing PSC in Cooler/Freezer	Average NCP Demand (kW)	0.0660	0.0891	135%
	Summer CP Demand (kW)	0.0510	0.0891	175%
	Energy (kWh)	581	758	130%
ECM Replacing SP in Cooler/Freezer	Average NCP Demand (kW)	0.2010	0.0999	50%
	Summer CP Demand (kW)	0.1810	0.0999	55%
	Energy (kWh)	1,757	874*	50%
ECM Replacing Display Case Motor	Average NCP Demand (kW)	0.0456	0.0990	217%
	Summer CP Demand (kW)	0.0410	0.0990	241%
	Energy (kWh)	356	844	237%

* Cadmus produced the NEEP Commercial Refrigeration Load Shape Study in 2015 based on field metering. Using the average rated hp from the distribution presented in Table 15, the NEEP Study predicts annual energy and summer peak demand savings of 770 kWh and 0.088 kW for SP to ECM cooler retrofits and 979 kWh and 0.112 kW for SP to ECM freezer retrofits. Therefore, the savings values will depend greatly on the relative mix of coolers and freezers.

The main factor affecting the results of all three measures was the update to the input wattages and the weighting used to estimate the per-motor savings. For the PSC measure, this resulted in a reduction in savings. For the SP cooler, freezer, and display case measures, this resulted in an increase in the savings. Additionally, for the PSC and SP motor measures, a major factor affecting the results was an apparent clerical error in recording the per-motor savings associated with the SP and SP motors in the tracking database (refer to Table 10).

Table 15 lists the total claimed and adjusted savings for the three measures.

Table 15. Total Claimed and Adjusted Savings for ECM Motors

Measure	Claimed Savings			Adjusted Savings			Realization Rates		
	Energy (kWh) [A]	NCP Demand (kW) [B]	CP Demand (kW) [C]	Energy (kWh) [D]	NCP Demand (kW) [E]	CP Demand (kW) [F]	Energy [D/A]	NCP Demand [E/B]	CP Demand [F/C]
Display Case	571,380	73	77	1,355,079	159	159	237%	217%	207%
Walk-in PSC	1,189,489	136	151	513,269	60	60	43%	44%	40%
Walk-in SP	96,446	11	18	145,198	17	17	151%	151%	92%
Total	**1,857,315**	**220**	**246**	**2,013,547**	**236**	**236**	**108%**	**107%**	**96%**

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Conclusions and Recommendations

Conclusion 1. For the ECM motors measure group, the size of the motors being replaced vary greatly; there is up to five times difference between the hp rating for the smallest and largest motors in the tracking database. The actual savings for a group of motors will vary widely based on the proportion of various sizes in the tracking database population.

Recommendation 1. Calculate refrigeration ECM motor savings on a per hp basis rather than a per motor basis. Table 16 shows recommended per hp savings based on Cadmus's findings in the NEEP Commercial Refrigeration Load Shape Study which can be applied to both walk-in and display case measures.

Table 16. Recomended ECM Motor per hp Savings

Base Case Motor	Savings Per Horsepower	
	Energy (kWh)	NCP and CP (kW)
SP	11,359	1.3295
PSC	9,090	1.0640

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VFD on HVAC Fans and Pumps

DEC provided incentives for a total of 93 unique VFDs on HVAC Fan retrofit applications and 18 unique VFDs on HVAC Pump retrofit applications.

Table 17 and Table 18 show the deemed savings values in the applicable work paper as well as the savings shown in the tracking database for the evaluation period. DEC updated the tracking database values in 2014 based on an update memo provided by TecMarket Works.[10]

Table 17. DEC Deemed Savings for VFD on HVAC Fans

Savings	Savings per hp		
	Work Paper	Tracking Database (2013)	Tracking Database (2014-2015)
Average NCP Demand (kW)	0.1920	0.1600	0.1600
Summer CP Demand (kW)[11]	0.1720	0.2580	0.1570
Energy (kWh)	1,281	1,374	1,374

Table 18. DEC Deemed Savings for VFD on HVAC Pumps

Savings	Savings per hp		
	Work paper	Tracking Database (2013)	Tracking Database (2014-2015)
Average NCP Demand (kW)	0.5130	0.3050	0.3050
Summer CP Demand (kW)[12]	0.3210	0.5200	0.2990
Energy (kWh)	3,698	2,774	2,774

Work Paper Methodology

BuildingMetrics developed a set of commercial prototypical building models by using the DOE-2.2 building energy simulation program for each of the market segments defined such as hospitals, hotels, and large office buildings. The prototypes are based on the models used in the California Database for Energy Efficiency Resources studies, with appropriate modifications to adapt these models to local design practices and climate.[13]

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10 TecMarket Works. *Carolinas - Non-Residential Smart $aver - VFD Update Memo*. Technical Memorandum. February 2, 2012.

11 Cadmus could not find the source of the VFD on HVAC fans summer CP demand savings in the tracking database and, thus, assumes that they are based on DEC DSMore analysis.

12 Cadmus could not find the source of the VFD on HVAC pumps summer CP demand savings in the tracking database and, thus, assumes that they are based on DEC DSMore analysis.

13 These prototypes are described in more detail in Building Metrics, Inc., Duke Energy Measure Savings Database – Weather Sensitive Retrofit Measures for Residential and Commercial Buildings. Technical memorandum. July 2010.

The work paper estimates annual energy, summer peak, and winter peak demand savings based on differences between the simulated energy consumption and peak demand at the baseline and the measure efficiency levels. The work paper assumed that summer peak demand occurs during the month of July, while winter peak impacts were calculated during the month of January. The savings were based on a calculated average of savings from 75 models with different HVAC systems, building types, and locations (described in the Table 19).

Table 19 Variation in Work paper Model Inputs

Types	Location*	System Type
• Hospital • Hotel • Large Office	• Asheville, NC • Charlotte, NC • Greenville, NC • Indianapolis, IN • Cincinnati, OH	• VAV reheat with economizer with air cooled chiller (fan measure only) • VAV reheat with economizer with water cooled chiller (fan measure only) • CV reheat with economizer (pump measure only) • CV reheat with no economizer (pump measure only) • VAV reheat with economizer (pump measure only)

* Though the last two cities are not in the Carolinas, they were included in the work paper analysis.

The TecMarket Works memo used by DEC to update the savings in 2014 mapped all of the previous year's applications to the savings based on the specific building type and location to find more application specific savings for this measure. TecMarket Works calculated the average, per fan hp and per pump hp savings to inform to future projects.

Work Paper Methodology Adjustments Necessary

Cadmus used the results from a recent HVAC VFD load shape project performed by Cadmus on behalf of NEEP. The VFD Load Shape Study report, and accompanying MS Excel tool,[14] describe a measurement based study to determine the annual peak and hourly demand impacts from installations on HVAC fans and pumps. The study metered 392 individual HVAC motors with VFDs for over a year (June 2012 – September 2013). The study compared metered energy consumption of each motor to a baseline of either metered consumption (pre-installation, when available) or of the DOE2.2 modeled consumption of the system without a VFD. The results of the study, similar to those in the work paper, are summarized in terms of energy and demand savings per hp.

Though the study focuses on cities in the Northeast, one of the major observations of the study was that a variation in climate and outdoor air conditions had negligible impact on the load shape. This, and other key findings include the following:

- Variable speed drives frequently operate at constant speed.
- Operators may select constant speed operation over variable speed operation.

[14] The Cadmus Group. *Variable Speed Drive Load shape Project*. Northeast Energy Efficiency Partnership, n.d. Available online: http://www.neep.org/variable-speed-drive-load shape-study-final-report.

- Variable speed drive performance often does not track outside temperature.
- The savings estimates for each weather region are similar and similarly diverse.

Because of this, Cadmus concluded that the NEEP savings figures are applicable to DEC projects. Moreover, the aggregate results of the NEEP report included instances where the VFD installed motors were not operating at optimal efficiency (e.g., controls bypassed and running at full speed or single speed set by operator). This means that the average deemed savings figures, applied program-wide, will account for cases where the controls are not implemented as planned. Cadmus has encountered these cases in our verifications for Duke Energy Ohio.[15]

The NEEP study also shows that there is a large variation in the amount of savings depending on what type of HVAC pump the VFD is installed on. As shown in Table 20, for a VFD installed on a cooling water pump, a hot water pump, or a water source heat pump (WSHP) circulation pump, the typical savings ranged from 19% below to 34% above the average savings for all HVAC pumps. The variation between the two types of HVAC fans analyzed (supply and return) was not as large (±6%).

Because the tracking database did not contain enough information to determine the type of pump associated with each application, we could not make any adjustments based on these findings. In order to estimate more accurate program savings in the future, we recommend that the VFD on HVAC pumps measure be administered by pump duty (cooling water vs. hot water vs. WSHP).

Table 20. Comparison of Savings for VFDs on HVAC Pumps Depending on Pump Duty Based on NEEP Variable Speed Drive Load shape Project

Equipment Type	Savings per Pump (hp)			
	Energy (kWh)	Energy Difference from Average	Average NCP Demand (kW)	Average NCP Demand Difference from Average
Cooling Water Pump	1,633	-14.7%	0.1860	-14.8%
Hot Water Pump	1,548	-19.1%	0.1770	-18.9%
WSHP Circulation Pump	2,562	33.8%	0.2920	33.7%
Average All Pump	1,914	0.0%	0.2183	0.0%

Work Paper Adjustment Results

Table 21 and Table 22 show per hp adjusted savings figures for HVAC fans and pumps, respectively.

The main reason for the difference is because Cadmus based the adjusted savings on real-world metering as opposed to modeled savings. Table 23 and Table 24 show the claimed savings, the adjusted savings, and the realization rates for HVAC fans and pumps, respectively.

15 Cadmus. *Evaluation of the Smart $aver Nonresidential Custom Incentive Program in Ohio.* Evaluation, Measurement, & Verification for Duke Energy Ohio. November 15, 2015.

Table 21 Adjusted VFDs on HVAC Fans Measure Savings

Savings Parameter (per hp)	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Energy (kWh)	1,281	1,910	149%
Average NCP Demand (kW)	0.1920	0.2181	114%
Summer CP Demand (kW)	0.1720	0.2914	169%
Winter CP Demand (kW)	n/a	0.2990	n/a

Table 22 Adjusted VFDs on HVAC Pumps Measure Savings

Savings Parameter (per hp)	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Energy (kWh)	3,698	1,914	52%
Average NCP Demand (kW)	0.5130	0.2185	43%
Summer CP Demand (kW)	0.3210	0.1687	53%
Winter CP Demand (kW)	n/a	0.2408	n/a

Table 23. Total Claimed and Adjusted Savings for HVAC Fans

Savings	Total Savings (kWh)	Total NCP Savings (kW)	Total CP Savings (kW)
Claimed [A]	14,553,141	1,695	2,188
Adjusted [B]	20,236,854	2,310	3,086
Realization Rate [B/A]	139%	136%	141%

Table 24. Total Claimed and Adjusted Savings for HVAC Pumps

Savings	Total Savings (kWh)	Total NCP Savings (kW)	Total CP Savings (kW)
Claimed [A]	5,480,481	603	799
Adjusted [B]	3,781,949	432	333
Realization Rate [B/A]	69%	72%	42%

Conclusions and Recommendations

Conclusion 1. A recently completed metering study by Cadmus on behalf of NEEP showed that there is a large variation in the amount of savings depending on what type of HVAC pump the VFD is installed on. For a VFD installed on a cooling water pump, a hot water pump, or a WSHP circulation pump, the typical savings ranged from 19% below to 34% above the average savings for all HVAC pumps.

Recommendation 1. Calculate savings based on the pump's duty (cooling water vs. hot water vs. WSHP) as opposed to a general HVAC pump assumption. The recommended savings by pump duty cycle were shown in Table 20.

Conclusion 2. The savings for VFDs on HVAC Fans and Pumps depended on the quantity and the hp rating of the motors retrofitted. However, the hp rating of the motors were not always recorded or recorded accurately in the tracking database. Cadmus found this to be an issue in its review of the entire tracking database for measures where total savings depended on not just the quantity of the measure, but also additional parameters such as hp rating of the motors.

Recommendation 2. Record the quantitative parameters for measure saving determination consistently to facilitate total measure savings and program saving calculations.

Linear Fluorescent High Bay Fixtures Replacing HID

The linear fluorescent high bay measure group work paper identifies DEC savings resulting from retrofitting HID fixtures with high-output T5 and T8 linear fluorescent fixtures in two, three, four, and eight lamp configurations. DEC provides incentives for 11 measures identified in the work paper. DEC also provides incentives for one additional retrofit scenario, high-bay 2 lamp T8, even though the savings for this configuration were not addressed in the work paper. Table 25 and Table 26 summarize these 12 retrofit scenarios and the associated work paper energy and demand savings.

The high bay measure was part of an evaluation performed by TecMarket Works in 2011.[16] DEC applied evaluated savings prospectively in the tracking database after that evaluation. Therefore, as shown in Table 25 and Table 26, the values in the tracking database are different from those in the work paper. This current evaluation includes a review of the work paper methodology; however, the total adjusted savings are presented in comparison to the DEC claimed saving values in the tracking database at the end of this section.

Table 25. DEC Deemed Energy Savings for Linear Fluorescents High Bay

Efficient Fixture	Existing HID Fixture (W)	Savings per Fixture	
		Work Paper (kWh)	Tracking Database (kWh)
High Bay 2-L T5	150-249	300	561
High Bay 3-L T5	250-399	449	843
High Bay 4-L T5	400-999	882	1,748
High Bay 6-L T5	400-999	374	835
High Bay 8-L T5	750-999	1,514	2,842
2 High Bay 6-L T5	1,000	1,456	1,456
High Bay 2-L T8	150-249	n/a	513
High Bay 3-L T8	150-249	341	641
High Bay 4-L T8	250-399	616	1,124
High Bay 6-L T8	400-999	961	1,811
High Bay 8-L T8	400-999	649	1,218
2 High Bay 8-L T8 (single fixture 16 lamps)	1,000	2,005	2,005

16 TecMarket Works. *Evaluation of the Non-Residential Smart $aver Prescriptive Program in North and South Carolina: Results of a Results of a Process and Impact Evaluation*. Prepared for Duke Energy. Final: February 6, 2011 (Revised: June 16, 2011).

Table 26. DEC Deemed Average NCP and CP Demand Savings for Linear Fluorescents High Bay

Efficient Fixture	NCP Demand (kW)		CP Demand (kW)	
	Work Paper	Tracking Database	Work Paper	Tracking Database
High Bay 2-L T5 High Output	0.0720	0.0950	0.0684	0.0900
High Bay 3-L T5 High Output	0.1080	0.1430	0.1026	0.1354
High Bay 4-L T5 High Output	0.2120	0.2960	0.2014	0.2803
High Bay 6-L T5 High Output	0.0900	0.1410	0.0855	0.1335
High Bay 8-L T5 High Output	0.3640	0.4810	0.3458	0.4555
2 High Bay 6-L T5 High Output	0.3500	0.3500	0.3325	0.3325
High Bay 2-L T8	n/a	0.1261	n/a	0.1030
High Bay 3-L T8	0.0820	0.1090	0.0779	0.1032
High Bay 4-L T8	0.1480	0.1900	0.1406	0.1799
High Bay 6-L T8	0.2310	0.3060	0.2195	0.2878
High Bay 8-L T8	0.1560	0.2060	0.1482	0.1951
2 High Bay 8-L T8 (single fixture 16 lamps)	0.4820	0.4820	0.4579	0.4579

Work Paper Methodology

The work paper assesses the equivalency of various efficient high bay linear fluorescent fixtures with existing metal halide fixtures in terms of light output. The light output for each fixture is assumed to be equal to the mean lumens of the lamps in each fixture. By developing the equivalency based on mean lumens, the light output of a lamp at 40% of its rated life, the work paper has accounted for the depreciation in light output during the lifetime of a lamp. The work paper considers a differential light output of less than 25% as acceptable.

FES then compares the input wattages of equivalent existing and efficient fixtures to calculate energy and NCP demand savings. The work paper uses 4,160 annual hours based on the Focus on Energy deemed savings manual, using a 50/50 weighting of industrial and commercial hours of use values.[17] However, the value is not supported in the Focus on Energy deemed savings manual (the evaluation team calculates 4,238 using the same weighting method). The work paper assumed a CF of 0.95 which is an internal FES standard value. The work paper does not account for the interactive effects of lighting and HVAC.

Work Paper Adjustments Necessary

Cadmus found the work paper methodology reasonable in developing equivalent retrofit scenarios and assigning wattages to the baseline and efficient fixtures in each scenario. Note that the savings depend

[17] Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

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significant on the baseline fixture installed. Cadmus verified that the Prescriptive Program application specifies the baseline fixture for each measure.[18]

However, we found the following adjustments necessary:

We used the following saving algorithm from the Ohio TRM, which incorporates the interactive effects of lighting and HVAC in the adjusted saving calculation:

Energy Savings

$$\Delta kWh = (WATTS_{BASE} - WATTS_{EE}) * HOURS * (1 + WHF_E)/1{,}000$$

Where:

$WATTS_{BASE}$	=	connected wattage of the baseline fixtures
$WATTS_{EE}$	=	connected wattage of high-efficiency fixtures
HOURS	=	annual lighting operating hours
WHF_E	=	lighting-HVAC interaction factor

Summer CP Demand Reduction

$$\Delta kW = ((WATTS_{BASE} - WATTS_{EE}) * CF * (1 + WHF_D))/1{,}000$$

Where:

WHF_D	=	lighting-HVAC waste heat factor for demand and
CF	=	summer peak coincidence factor.

Cadmus used the weighted average HVAC interactive effects multipliers calculated by TecMarket Works in a previous evaluation of the high-performance linear fluorescents measure in the Carolinas, [19] which are 0.22 for demand and 0.042 for energy.

The work paper used 4,160 as the annual hours of operation for the metal halide lamps as a place-holder. The 2011 TecMarket Works evaluation of the high bay measure found that on average, the metered hours of use predicted about 2% fewer annual operating hours in North Carolina and 15% more annual hours of use in South Carolina compared with the participants self-reported hours of use. [20]

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18 Duke Energy. *North Carolina and South Carolina Lighting Smart $aver Prescriptive Incentive Application.* 1/2016 v3. Available online: http://www.duke-energy.com/pdfs/NC_Lighting.pdf

19 TecMarket Works. *Process and Impact Evaluation of the Non-Residential Smart $aver Prescriptive Program in the Carolina System: Lighting and Occupancy Sensors.* Prepared for Duke Energy. April 5, 2013.

20 TecMarket Works. *Evaluation of the Non-Residential Smart $aver Prescriptive Program in North and South Carolina: Results of a Results of a Process and Impact Evaluation.* Prepared for Duke Energy. Final: February 6, 2011 (Revised: June 16, 2011. P. 60).

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Cadmus calculated the average self-reported and logged hours of use weighted by the evaluated savings in the 2011 TecMarket Works evaluation. The ratio of weighted average logged over self-reported hours of use in the evaluation for both states together was 117%.

Cadmus calculated the average self-reported hours of use for the participants in the current tracking database weighted by claimed savings. We used the self-reported hours of use from 687 applications in the tracking database in our calculation. Cadmus increased the self-reported average hours of use by the ratio of logged over self-reported hours of use calculated based on the TecMarket Works evaluation. We used this value as the average annual hours of use in the current evaluation. Table 27 lists the results.

Table 27. Adjusted Hours of Use Calculation Based on Self-reported Annual Hours of Operation

	Annual Hours of Operation
Tracking Database Self-Reported Weighted Average [A]	4,488
Ratio of Logged / Self-Reported from Previous Evaluation [B]	1.17
Adjusted Hours of Use [A x B]	5,246

We also calculated the CF verified by TecMarket Works in 2011, weighted by the evaluated savings (0.97) and deemed the work paper CF value of 0.95 as reasonable.

Work Paper Adjustment Results

Table 28, Table 29, and Table 30 show the adjusted savings values and how they compare to the work paper values. The main factors causing the higher kWh savings are the addition of HVAC interactive effects and the adjusted annual hours of operation. The main factor causing the higher kW savings is the addition of HVAC interactive effects.

Table 28. Adjusted Linear Fluorescent High Bay Measure Energy Savings

Efficient Fixture	Work Paper (kWh) [A]	Adjusted Savings (kWh) [B]	Adjustment Factor [B/A]
High Bay 2-L T5	300	394	131%
High Bay 3-L T5	449	591	131%
High Bay 4-L T5	882	1,159	131%
High Bay 6-L T5	374	492	131%
High Bay 8-L T5	1,514	1,990	131%
2 High Bay 6-L T5	1,456	1,914	131%
High Bay 2-L T8	n/a	621	n/a
High Bay 3-L T8	341	448	131%
High Bay 4-L T8	616	809	131%
High Bay 6-L T8	961	1,263	131%
High Bay 8-L T8	649	853	131%
2 High Bay 8-L T8 (or single fixture 16 lamps)	2,005	2,635	131%

Table 29. Adjusted Linear Fluorescent High Bay Measure CP Demand Savings

Efficient Fixture	Work Paper (kW) [A]	Adjusted Savings (kW) [B]	Adjustment Factor [B/A]
High Bay 2-L T5	0.0684	0.0834	122%
High Bay 3-L T5	0.1026	0.1252	122%
High Bay 4-L T5	0.2014	0.2457	122%
High Bay 6-L T5	0.0855	0.1043	122%
High Bay 8-L T5	0.3458	0.4219	122%
2 High Bay 6-L T5	0.3325	0.4057	122%
High Bay 2-L T8	n/a	0.1315	n/a
High Bay 3-L T8	0.0779	0.0950	122%
High Bay 4-L T8	0.1406	0.1715	122%
High Bay 6-L T8	0.2195	0.2677	122%
High Bay 8-L T8	0.1482	0.1808	122%
2 High Bay 8-L T8 (or single	0.4579	0.5586	122%

Table 30. Adjusted Linear Fluorescent High Bay Measure NCP Demand Savings

Efficient Fixture	Work Paper (kW) [A]	Adjusted (kW) [B]	Adjustment Factor [B/A]
High Bay 2-L T5	0.0720	0.0878	122%
High Bay 3-L T5	0.1080	0.1318	122%
High Bay 4-L T5	0.2120	0.2586	122%
High Bay 6-L T5	0.0900	0.1098	122%
High Bay 8-L T5	0.3640	0.4441	122%
2 High Bay 6-L T5	0.3500	0.4270	122%
High Bay 2-L T8	n/a	0.1385	n/a
High Bay 3-L T8	0.0820	0.1000	122%
High Bay 4-L T8	0.1480	0.1806	122%
High Bay 6-L T8	0.2310	0.2818	122%
High Bay 8-L T8	0.1560	0.1903	122%
2 High Bay 8-L T8 (single	0.4820	0.5880	122%

A summary of the savings associated with all linear fluorescent high bay applications in the evaluation period, including the claimed savings, the adjusted savings, and the realizations rates are shown in Table 31. Cadmus used the tracking database per-unit savings for each efficient fixture to calculate claimed savings. As mentioned previously and noted in Table 25 and Table 26, the DEC tracking database per-unit savings and hence the total claimed savings calculated by Cadmus, include the realization rates from the previous evaluation (1.77 and 1.14 for energy and CP demand respectively in NC and 1.62 and 1.02 for energy and CP demand respectively in SC). Therefore, the realization rates noted in Table 31 are lower than the adjustment rates shown for the work paper savings in the previous tables.

Table 31. Total Claimed and Adjusted Savings for the Linear Fluorescent High Bay Measure

Savings	Energy (kWh)	NCP Demand (kW)	CP Demand (kW)
Claimed [A]	85,708,927	14,570	13,758
Adjusted [B]	58,154,366	12,976	12,327
Realization Rate [B/A]	68%	89%	90%

Conclusions and Recommendations

None.

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High Performance Linear Fluorescent

The high performance linear fluorescent measure group includes 38 unique measures:

- Nine measures provide incentives for retrofitting standard T8 fixtures with *high-performance* or *reduced-wattage* T8s as designated by the Consortium for Energy Efficiency (CEE).[21]
- Ten measures provide incentives for retrofitting standard or high output T12 fixtures with *high-performance* or *reduced-wattage* T8 fixtures as designated by CEE.
- Nineteen measures provide incentives for retrofitting four-foot T12 fixtures with regular or high output T8 or T5 lamps and retrofitting eight-foot T12 fixtures with *high-performance* T8s. DEC discontinued these measures as of January 2013 in response to the federal standards that went into effect in July of 2012. The federal standards include efficacy requirements that cannot be met by standard T12 lamps (with a few exception) and instead can be met with T8 lamps. Although there are instances of incentives paid to these measures in the DEC tracking database, the evaluation team assumed that these incentives were applied for before the measures were discontinued in 2013 (and paid for after 2013). Therefore, these measures are not included in the work paper review.

The high-performance linear fluorescent measure was part of an evaluation performed by TecMarket Works in 2013.[22] DEC applied evaluated savings prospectively in the tracking database after this evaluation. Therefore, as shown in Table 32, the values in the tracking database are different from those in the FES work paper. This current evaluation includes a review of the work paper methodology; however, the total adjusted savings are presented in comparison to the DEC claimed saving values in the tracking database at the end of this section.

[21] The qualifying lists can be found at: https://www.cee1.org.

[22] TecMarket Works. *Process and Impact Evaluation of the Non-Residential Smart $aver Prescriptive Program in the Carolina System: Lighting and Occupancy Sensors.* Prepared for Duke Energy. April 5, 2013.

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Table 32. DEC Deemed Savings for High Performance Linear Fluorescents

Measure	Energy		NCP Demand		CP Demand	
	Work Paper (kWh)	Tracking Database (kWh)	Work Paper (kW)	Tracking Database (kW)	Work Paper (kW)	Tracking Database (kW)
High-Performance (HP) T8 Replacing T12s						
HP T8 32W - 4' 1 Lamp	43	75	0.0118	0.0190	0.0106	0.0160
HP T8 32W - 4' 2 Lamp	58	101	0.0158	0.0255	0.0142	0.0215
HP T8 32W - 4' 3 Lamp	97	169	0.0265	0.0427	0.0238	0.0360
HP T8- 32W - 4' 4 Lamp	111	192	0.0301	0.0486	0.0271	0.0410
HP T8 Replacing Standard T8s						
HP T8 32W - 4' 1 Lamp	19	33	0.0053	0.0083	0.0047	0.0068
HP T8 32W - 4' 2 Lamp	31	54	0.0083	0.0136	0.0075	0.0109
HP T8 32W - 4' 3 Lamp	35	61	0.0095	0.0154	0.0085	0.0123
HP T8- 32W - 4' 4 Lamp	52	90	0.0141	0.0228	0.0127	0.0191
Low-Wattage (LW) T8 Replacing T8s						
LW 25/28W - 4' 1 Lamp	29	50	0.0079	0.0127	0.0071	0.0097
LW 25/28W - 4' 2 Lamp	48	83	0.0131	0.0211	0.0118	0.0160
LW 25/28W - 4' 3 Lamp	62	108	0.0170	0.0272	0.0153	0.0208
LW 25/28W - 4' 4 Lamp	92	160	0.0250	0.0404	0.0225	0.0307
LW T8 Replacing T12s						
LW 25/28W - 4' 1 Lamp	53	92	0.0144	0.0232	0.0130	0.0196
LW 25/28W - 4' 2 Lamp	76	132	0.0206	0.0333	0.0185	0.0280
LW 25/28W - 4' 3 Lamp	125	217	0.0340	0.0548	0.0306	0.0463
LW 25/28W - 4' 4 Lamp	151	262	0.0410	0.0662	0.0369	0.0559
HP T8 Replacing 8' HO T12s						
HP T8 32W - 4' 2 Lamp	123	213	0.0333	0.0537	0.0300	0.0454
HP T8- 32W - 4' 4 Lamp	225	389	0.0610	0.0985	0.0549	0.0831
LW T8 Replacing T8 – Lamp Only						
LW T8 – 4’ 1 lamp	15	26	0.0040	0.0066	0.0036	0.0054

Work Paper Methodology

The work paper uses common T12 and T8 wattages for the baseline fixtures and qualifying *high-performance* and *reduced-wattage* system wattages listed by the CEE for the replacements fixtures. Wattages for *reduced-wattage* replacement fixtures are determined based on a weighted average of 25W and 28W CEE qualified *reduced-wattage* T8 systems. Wattages for *high-performance* replacement fixtures are determined based on a weighted average of qualified *high-performance* fixtures using a low ballast factor (LBF), normal ballast factor (NBF), and high ballast factor (HBF). The work paper makes the following assumptions for calculating the weighted average wattage for the high-performance replacement fixtures:

- Four-foot T12 and T8 systems are replaced with *high-performance* or *reduced-wattage* T8 systems with 75% LBF ballasts and 25% NBF ballasts.
- Eight-foot T12 systems are replaced with *high-performance* systems with 100% NBF ballasts.
- Eight-foot T12 high output systems are assumed to be replaced with *high-performance* systems with 50% NBF ballasts and 50% HBF ballasts.

The work paper uses 3,680 annual hours of use based on the Focus on Energy deemed savings manual.[23] Cadmus could not verify this value based on the same reference (3,730 is the commercial building hours of use according to the manual). The work paper assumed a CF of 0.90 which is an internal FES standard value. The work paper does not account for the interactive effects of lighting and HVAC.

Work Paper Adjustments Necessary

Cadmus found the work paper methodology in assigning input wattages to the baseline and efficiency lighting fixtures reasonable. We made the following adjustments:

- We used the common lighting saving algorithm presented in the Linear Fluorescent High Bay Fixtures Replacing HID section, which incorporates the interactive effects of lighting and HVAC in the adjusted saving calculation. We used the following weighted average energy and demand waste heat factors determined in the 2013 evaluation of this measure by TMW:[24]
    - WHFD = 0.220
    - WHFE = 0.042

[23] Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

[24] TecMarket Works. *Process and Impact Evaluation of the Non-Residential Smart $aver Prescriptive Program in the Carolina System: Lighting and Occupancy Sensors*. Prepared for Duke Energy. April 5, 2013. p.25.

- The work paper used 3,680 as the annual hours of operation for linear fluorescent lamps. The 2013 TecMarket Works evaluation of the high performance linear fluorescent measure found that on average, the metered hours of use predicted 14% more than the participant self-reported hours of use, and 170% times more operating hours than the 3,680 assumption in the work paper.[25] The TecMarket Works logged and self-reported hours of use were weighted by the evaluated savings in the evaluation. Of the 1,085 applications recorded for this measure group in the tracking database, 494 had self-reported hours of use. Cadmus calculated the average self-reported hours of use by application, weighted by the claimed savings for each application. Cadmus increased the self-reported average hours of use by the ratio of logged over self-reported hours of use calculated in the 2013 TecMarket Works evaluation. Cadmus used this value as the average annual hours of use in the adjusted savings. The results are summarized in Table 33.

Table 33. Adjusted Hours of Use Calculation Based on Self-reported Annual Hours of Operation

	Annual Hours of Operation
Tracking Database Self-reported Weighted Average [A]	4,563
Ratio of Logged / Self-reported from TecMarket Works 2013 Evaluation [B]	1.14
Adjusted Hours of Use [C] (=AxB)	5,202

- In lieu of the 0.9 CF used in the work paper, an internal FES value, the evaluation team used the weighted average verified CF determined in the 2013 TecMarket Works evaluation (0.76).[26]

Work Paper Adjustment Results

Table 34 , Table 35, and Table 36 show the adjusted savings figures and how they compare to the work paper values. The factors causing the higher kWh savings are the addition of HVAC interactive effects and the adjusted annual hours of operation. The factors affecting the demand savings are the addition of HVAC interactive effects and the adjusted CF.

A summary of the savings associated with all high performance linear fluorescent applications in the evaluation period, including the claimed savings, the adjusted savings, and the realizations rates are shown in Table 36. Cadmus used the per-unit savings and the quantities recorded in the tracking database for each measure to calculate claimed savings. As mentioned previously and noted in Table 32, the program tracking savings recorded by DEC and hence the total claimed savings calculated by Cadmus, include the realization rate from the previous evaluation (1.73, 1.61, 1.47 for energy, NCP demand, and CP demand savings on average respectively).Therefore, the realization rates noted in Table 36 are lower than the adjustment rates shown for the work paper savings in the tables above.

[25] Ibid. Pp 23-24.

[26] Ibid. P 23.

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Table 34. Adjusted High Performance Linear Fluorescent Measure Energy Savings

Measure	Work Paper (kWh) [A]	Adjusted Savings (kWh) [B]	Adjustment Factor [B/A]
HP T8 Replacing T12s			
HP T8 32W - 4' 1 Lamp	43	64	147%
HP T8 32W - 4' 2 Lamp	58	86	147%
HP T8 32W - 4' 3 Lamp	97	143	147%
HP T8- 32W - 4' 4 Lamp	111	163	147%
HP T8 Replacing Standard T8s			
HP T8 32W - 4' 1 Lamp	19	28	147%
HP T8 32W - 4' 2 Lamp	31	45	147%
HP T8 32W - 4' 3 Lamp	35	51	147%
HP T8- 32W - 4' 4 Lamp	52	76	147%
LW T8 Replacing T8s			
LW 25/28W - 4' 1 Lamp	29	43	147%
LW 25/28W - 4' 2 Lamp	48	71	147%
LW 25/28W - 4' 3 Lamp	62	92	147%
LW 25/28W - 4' 4 Lamp	92	136	147%
LW T8 Replacing T12s			
LW 25/28W - 4' 1 Lamp	53	78	147%
LW 25/28W - 4' 2 Lamp	76	112	147%
LW 25/28W - 4' 3 Lamp	125	184	147%
LW 25/28W - 4' 4 Lamp	151	222	147%
HP T8 Replacing 8'HO T12s			
HP T8 32W - 4' 2 Lamp	123	180	147%
HP T8- 32W - 4' 4 Lamp	225	331	147%
LW T8 Replacing T8 – Lamp Only			
LW T8 – 4' 1 lamp	15	22	147%

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Table 35. Adjusted High Performance Linear Fluorescent Measure Demand Savings

Measure	NCP (kW)			CP (kW)		
	Work Paper [A]	Adjusted Savings [B]	Adjustment Factor [B/A]	Work Paper [C]	Adjusted Savings [D]	Adjustment Factor [D/C]
HP T8 Replacing T12s						
HP T8 32W - 4' 1 Lamp	0.0118	0.0143	122%	0.0106	0.0109	103%
HP T8 32W - 4' 2 Lamp	0.0158	0.0193	122%	0.0142	0.0146	103%
HP T8 32W - 4' 3 Lamp	0.0265	0.0323	122%	0.0238	0.0245	103%
HP T8- 32W - 4' 4 Lamp	0.0301	0.0367	122%	0.0271	0.0279	103%
HP T8 Replacing Standard T8s						
HP T8 32W - 4' 1 Lamp	0.0053	0.0064	122%	0.0047	0.0049	103%
HP T8 32W - 4' 2 Lamp	0.0083	0.0101	122%	0.0075	0.0077	103%
HP T8 32W - 4' 3 Lamp	0.0095	0.0115	122%	0.0085	0.0088	103%
HP T8- 32W - 4' 4 Lamp	0.0141	0.0172	122%	0.0127	0.0131	103%
LW T8 Replacing T8s						
LW 25/28W - 4' 1 Lamp	0.0079	0.0097	122%	0.0071	0.0073	103%
LW 25/28W - 4' 2 Lamp	0.0131	0.0160	122%	0.0118	0.0121	103%
LW 25/28W - 4' 3 Lamp	0.0170	0.0207	122%	0.0153	0.0157	103%
LW 25/28W - 4' 4 Lamp	0.0250	0.0305	122%	0.0225	0.0232	103%
LW T8 Replacing T12s						
LW 25/28W - 4' 1 Lamp	0.0144	0.0176	122%	0.0130	0.0134	103%
LW 25/28W - 4' 2 Lamp	0.0206	0.0251	122%	0.0185	0.0191	103%
LW 25/28W - 4' 3 Lamp	0.0340	0.0414	122%	0.0306	0.0315	103%
LW 25/28W - 4' 4 Lamp	0.0410	0.0500	122%	0.0369	0.0380	103%
HP T8 Replacing 8'HO T12s						
HP T8 32W - 4' 2 Lamp	0.0333	0.0406	122%	0.0300	0.0309	103%
HP T8- 32W - 4' 4 Lamp	0.0610	0.0744	122%	0.0549	0.0566	103%
LW T8 Replacing T8 – Lamp Only						
LW T8 – 4’ 1 lamp	0.0040	0.0049	122%	0.0036	0.0037	103%

Table 36. Total Claimed and Adjusted Energy Savings for High Performance Linear Fluorescents

Savings	Energy (kWh)	NCP Demand (kW)	CP Demand (kW)
Claimed [A]	17,420,130	4,404	3,568
Adjusted [B]	14,767,697	3,324	2,526
Realization Rate [B/A]	85%	75%	71%

Conclusions and Recommendations

None.

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LED Lamps and Downlights

The LED lamps measure provides incentives for replacing incandescent bulbs with ENERGY STAR® LEDs. The work paper assumes a 60W incandescent bulb as the baseline in 2012. The 60W incandescent bulb was subject to EISA 2007 requiring that a former 60W lamp manufactured and sold on or after January 1, 2014, use 43W or less, while providing the same amount of light.[27] Therefore, the work paper (and DEC) changed the baseline for the LED lamps measure in 2014 to reflect the 43W minimum standard. The deemed energy and demand savings for this measure changed from 2013 to 2014 as a result in the tracking database.

The LED downlights measure provides incentives for replacing 60W to 100W incandescent bulbs with ENERGY STAR qualified LED downlights of 18W or less.

Table 37 shows deemed savings per lamp for LED lamps and downlights in 2013 and beyond.

Table 37. DEC Deemed Savings for LED Lamps and Downlights

Savings	Energy (kWh)		NCP Demand (kW)		CP Demand (kW)	
Evaluation Year	2013	2014-2015	2013	2014-2015	2013	2014-2015
LED Lamps	177	114	0.0481	0.0310	0.0432	0.0310
LED Downlights	195	195	0.0530	0.0530	0.0477	0.0477

Work Paper Methodology

The LED lamps and downlights work paper includes the following assumptions:

LED Lamp Assumptions

- Existing watts/fixture = 60W (2013); 43W (2014 and beyond)
- Efficient watts/fixture = 12W
- CF = 0.77
- Annual Operating Hours = 3,680

LED Downlight Assumptions

- Existing watts/fixture = 65W
- Baseline watts/fixture = 12W
- CF = 0.77
- Annual operating hours = 3,680

[27] The EISA 2007 minimum efficacy standards applied to 100W lamps in 2012, 75W lamps in 2013, and 60W/45W lamps in 2014.

The work paper uses 3,680 as the annual hour of use based on the Focus on Energy deemed savings manual.[28] Cadmus could not verify this value based on the same reference (3,730 is the commercial building hours of use according to the manual). The work paper assumed a CF of 0.90, which is an internal FES standard value. The work paper does not account for the interactive effects of lighting and HVAC.

Work Paper Adjustments Necessary

Cadmus used the weighted average HVAC interactive effects multipliers calculated by TecMarket Works in a previous evaluation of the high-performance linear fluorescents measure in the Carolinas, [29] which are 0.22 for demand and 0.042 for energy. We also determined the Focus on Energy deemed savings manual CF of 0.77 is appropriate for the adjusted peak demand saving calculations. The remaining adjustments are described separately for LED lamps and downlights.

LED Lamp Assumptions

Cadmus found the efficient wattage assumption (12W) for the LED lamps measure is appropriate. We calculated 12.45W as the average wattage of the 60W equivalent LED lamps in the ENERGY STAR data base available during the evaluation period. [30]

However, Cadmus found that the 2013 baseline wattage assumption (60W) for the LED does not agree with the average wattage of incandescent lamps in use in commercial and industrial buildings according to the 2010 characterization of the lighting market as issued by the Department of Energy (52W).[31] We revised the baseline wattage assumption from 60W to 52W in the adjusted saving calculations for 2013. We determined that in 2014 and 2015 the EISA baseline of 43W is appropriate.

The weighted average of self-reported hours of use for LED lamps in the tracking database is 4,358. In order to calculate this weighted average hours of use, Cadmus used 1,030 of the 1,553 applications for LED lamps in the DEC tracking database, which had self-reported hours of use recorded. Cadmus calculated the average self-reported hours of use, by application, weighted by the claimed savings for each application. Cadmus used 4,358 as the adjusted hours of use.

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[28] Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

[29] TecMarket Works. *Process and Impact Evaluation of the Non-Residential Smart $aver Prescriptive Program in the Carolina System: Lighting and Occupancy Sensors.* Prepared for Duke Energy. April 5, 2013.

[30] ENERGY STAR-certified lamps available after 2012, but before July 2015, filtered to 700-1100 lumens in brightness, excluding the decorative lamp category. The full database is available for download at: https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Light-Bulbs

[31] U.S. Department of Energy. *U.S. Lighting Market Characterization 2010*. 2013.

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LED Downlight Assumptions

Cadmus found the work paper's 60W average wattage is appropriate given the federal standards that took effect in July 2012. We calculated 72W as the average wattage of incandescent reflector lamps in downlights in commercial and industrial buildings according to the 2010 U.S. Lighting Market Characterization Report.[32] However, the DOE standards increased average efficacy of reflector lamps manufactured for sale and reduced the average wattage of available reflector lamps by as much as 10W.[33]

Cadmus calculated 15W as the average wattage of directional lamps rated for enclosed fixtures in the ENERGY STAR data base available during the evaluation period.[34] Given the relatively small change between this and the wattage calculated in the work paper (12W), we decided to not adjust the baseline or efficient wattages for this measure.

There were 143 applications in the DEC tracking database for this measure, and only 127 had self-reported hours of use recorded. Therefore, we used the average annual hours of use between commercial and industrial uses in the Focus on Energy manual, which is 4,238.

Work Paper Adjustment Results

Table 38 and Table 39 show the adjusted savings figures and how they compare to the work paper values. The main factors causing the higher kWh savings are the adjusted annual hours of operation. The main factor causing the higher CP demand savings is the addition of HVAC interactive effects. Due to a reduction in the adjusted CF, CP demand increased only slightly.

Table 38. Adjusted LED lamps Measure Savings

Savings Parameter	Work Paper		Adjusted		Adjustment Factor (2013) [C/A]	Adjustment Factor (2014-2015) [D/B]
	2013 [A]	2014-2015 [B]	2013 [C]	2014-2015 [D]		
Energy (kWh/year)	177	114	182	141	103%	123%
NCP (kW)	0.0480	0.0310	0.0488	0.0378	102%	122%
CP (kW)	0.0432	0.0279	0.0376	0.0291	87%	104%

32 US Department of Energy. *U.S. Lighting Market Characterization 2010*. 2013.

33 In a Cadmus internal assessment, the average of available incandescent reflector lamps wattage reduced by 9W within a year after EISA regulations took effect in California.

34 Directional lamps available after 2012 but before July 2015, filtered to 600 to 1,500 lumens in brightness, rated for enclosed fixtures. The full database is available for download at: https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Light-Bulbs

Table 39. Adjusted LED Downlights Measure Savings

Savings Parameter	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Energy (kWh/year)	195	234	120%
NCP (kW)	0.0530	0.0647	122%
CP (kW)	0.0477	0.0498	104%

A summary of the savings associated with all LED lamps and downlights applications in the evaluation period, including the claimed savings, the adjusted savings, and the realizations rates, are shown in Table 40 and Table 41.

Table 40. Total Claimed and Adjusted Energy Savings for LED Lamps (2013 – 2015)

Savings	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Energy (kWh/year)	16,471,533	19,376,927	118%
NCP (kW)	4,476	5,206	116%
CP (kW)	4,028	4,009	100%

Table 41. Total Claimed and Adjusted Energy Savings for LED Downlights

Savings	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Energy (kWh/year)	2,025,100	2,430,118	120%
NCP (kW)	550	671	122%
CP (kW)	495	517	104%

Conclusions and Recommendations

None.

VFDs on Process Pumps

DEC applied a deemed savings per hp for each VFD installed on an industrial process pump that received incentives to calculate the energy and demand savings for eight applications. Table 42 shows the savings values in the work paper as well as the savings shown in the tracking database during the evaluation period. The values in the tracking database are different from those in the work paper because they were updated in 2013 based on an update memo prepared by TecMarket Works in 2012.[35]

Table 42. DEC Deemed Savings for VFDs on Process Pumps

Savings	Savings per hp	
	Work paper	Tracking Database
Average NCP Demand (kW)	0.2480	0.2600
Summer CP Demand (kW)	0.2480	0.2600
Energy (kWh)	912	957

Work Paper Methodology

The work paper calculated the savings figures by comparing the modeled energy consumption of a pumped system utilizing throttling control against one utilizing VFD control with a flow profile that averages 70% flow. Using throttling as the base case control scheme is appropriate because it is a more common control method in industrial applications. Additionally, the measure savings are more conservatively estimated using a throttling control as the base case control scheme than a bypass loop.

The work paper utilizes a curve fit for a 20 hp pump.

The work paper uses 3,680 hours based on the Focus on Energy deemed savings manual.[36] Cadmus could not verify this value based on the same reference (3,730 is the commercial building hours of use according to the manual).

The work paper assumes a CF of 0.78 that was taken from a NYSERDA program. However the TecMarket update memo and the tracked savings database, assumes a CF of 1.0.

The paper did not provide a source for the assumed motor efficiency (92%). However, the assumed efficiency is reasonable when compared to the average minimum efficiency from the EISA efficiency standards for motor sizes 5 to 50 hp. The work paper assumed a full load motor load factor of 85% for industrial processes.

35 TecMarket Works. *Carolinas - Non-Residential Smart $aver - VFD Update Memo.* Technical Memorandum. February 2, 2012.

36 Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

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Work Paper Methodology Adjustments Necessary

While the work paper allows DEC to assign a single energy or demand saving figure per VFD on industrial pump, Cadmus found large uncertainty in the inputs and assumptions used to calculate this saving figure. There is significant variability in sizing, configuration, and operation of pumps (including the operational hours, the pressure difference through the pump, the pump flow profile, and even the fluid being pumped). We recommend including this measure in the Custom Program in the future. However, for the applications submitted during the evaluation period, Cadmus made the following adjustments:

- Used three typical flow profiles as opposed to a single flow profile more accurately represents all possible VFD retrofit scenarios. We used the average savings resulting from 60%, 70%, and 80% flows, as opposed to a single 70%.
- Assumed a full load motor load factor of 75%, based on the review team's experience. This is a more conservative estimate than the work paper.
- Used a generic performance curve for both base and measure cases instead of a single pump curve for a 20 hp pump.[37] The generic curve is an approximation based on a variety of pump configurations, whereas the work paper model assumes a single, specific, pump configuration.
- Assumed annual hours of 3,733 based on a national market assessment study of industrial electric motors.[38] This number is slightly higher than the hours used in the work paper. This estimate is specific to process pumping systems. This is the weighted average, based on the distribution of pump motor sizes, of the national average hours of operation for pump applications for motor sizes 1 to 50 hp. The self-reported operating hours in the tracking database ranged from 21% less to 131% greater than the assumed hours of operation in the DEC work paper. The updated hours are within less than 1% of the average of the self-reported hours.
- Assumes that the summer coincident and non-coincident kW savings are the same as process pumps are typically not affected seasonally or by weather. This assumption follows the methodology of the FES work paper.

Work Paper Adjustment Results

Table 43 shows the adjusted savings figures and how they compare to the program tracking values. The main factors affecting the higher kWh savings is an increase in the assumed hours of operation. The main factors affecting the lower kW savings is a lower assumed full load motor load factor of the pumps.

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37 Bonneville Power Administration. ASD Calculator for Fan & Pump Applications – Summary of information provided in Flow Control. Westinghouse publication, Bulletin B-851, F/86/Rev–CMS 8121.

38 United States Industrial Electric Motor Systems Market Opportunities Assessment. December 2002. p. B-2 <http://www1.eere.energy.gov/industry/bestpractices/pdfs/mtrmkt.pdf

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Table 43. Adjusted VFDs on Process Pumps Measure Savings

Savings Parameter	Work Paper	Adjusted Savings	Adjustment Factor
Average NCP Demand (kW)	0.2480	0.2090	84%
Summer CP Demand (kW)	0.2480	0.2090	84%
Energy (kWh)	912.00	1,012.00	111%

A summary of each application for this measure in the evaluation period, including the originally claimed savings, the adjusted savings, and the realizations rates are shown in Table 44.

Conclusions and Recommendations

Conclusion 1. Due to the great variability in pump sizing and configuration, Cadmus did not find an effective or accurate method to determine the average savings resulting from retrofitting an existing pump with a VFD.

Recommendation 1. To accurately assess the savings potential of each VFDs on process pumps application, administer incentives for this measure though the Custom Program.

Table 44. Total Claimed and Adjusted VFDs on Process Pump Savings

Savings	Total Savings (kWh)	Total NCP Savings (kW)	Total CP Savings (kW)
Claimed [A]	674,734	183	183
Adjusted [B]	732,495	147	147
Realization Rate [B/A]	109%	80%	80%

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VSDs on Air Compressors

DEC applied a deemed savings per hp for each compressor to calculate energy and demand savings for 27 applications. The savings are significantly affected by the base case control scheme; therefore, the work paper provides three sets of savings for variable displacement, load/unload, and modulation. Table 41 shows the deemed savings according to the work paper.

Table 45. DEC Deemed Savings for VSDs on Air Compressors

Base Case	Number of Applications	Savings	Savings per hp
Variable Displacement	1	Average NCP Demand (kW)	0.0450
		Summer CP Demand (kW)	0.0450
		Energy (kWh)	188
Load/Unload	4	Average NCP Demand (kW)	0.1210
		Summer CP Demand (kW)	0.1210
		Energy (kWh)	501
Modulation	22	Average NCP Demand (kW)	0.1510
		Summer CP Demand (kW)	0.1510
		Energy (kWh)	629

The values in the tracking database match the work paper values. However, there are three measure descriptions for the VSDs on air compressors measure group in the tracking database:

- VSDs on Air Compressors
- VSDs on Air Compressors replacing load/unload
- VSDs on Air Compressors replacing variable displacement

The load/unload and variable displacement base cases are distinguished in the database. However, there are no measure descriptions for the modulation base case. Cadmus could not verify the base cases associated with the applications recorded under the *VSDs on Air Compressors* measure description (and most of the applications are recorded under this measure code). Since the savings assigned by DEC to these applications match those in the work paper for the modulation base case, Cadmus assumed that the base case for the retrofit in these applications is modulation. In order to improve program tracking in the future, each application should be specifically assigned to one of the three base cases in the tracking database.

Work Paper Methodology

The work paper algorithms used to determine savings are based on the percentage of kW input versus the percentage of capacity for various air compressor control types published by the Compressed Air Challenge (note below).[39]

Modulating Control

$kW_{Mod} = \text{Max } kW_{Mod} * (\% \text{ Max Flow}_{Mod} * 0.3 + 0.7)$

Load/No Load Control

$kW_{L/NL} = \text{Max } kW_{L/NL} * (0.25 + 1.166 * \% \text{ Max Flow}_{L/NL} - 0.416 * \% \text{ Max Flow}_{L/NL}{}^2)$

Variable Displacement

$kW_{VD} = \text{Max } kW_{VD} * (0.77 * \% \text{ Max Flow}_{VD} + 0.23)$

Variable Speed Control

$kW_{VFD} = \text{Max } kW_{VFD} * \% \text{ Max Flow}_{VFD}$

Where:

Max kW = Compressor input power as design cfm
% Max Flow = Compressed air max design cfm

The work paper also includes these assumptions:

- The full load performance of each base case and the measure case was taken from Compressed Air and Gas Institute (CAGI) datasheets of Ingersoll Rand 100 hp, air-cooled, oil-injected units at 100 pounds per square inch utilizing the four different output control methods (modulating, load/no load, variable displacement, and variable speed control).
- The annual operating hours were assumed to be 4,160, based on 80 hours per week, 52 weeks a year. This value was rounded from the average operating hours for all manufacturing motors under 200 hp from the Department of Energy's (DOE's) market assessment of industrial electrical motors.[40]
- Average flows were assumed at 75% full load for energy and demand savings, this provides somewhat conservative savings, since the lower the load factor the greater the savings for VSD control. This is what was used in the "%Max Flow" variables in the above equations.

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[39] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Compressed Air Challenge, *Improving Compressed Air System Performance*, DOE/GO-102003-182. November 2003. Accessed online: https://www1.eere.energy.gov/manufacturing/tech_assistance/pdfs/compressed_air_sourcebook.pdf

[40] U.S. Department of Energy. United States Industrial Electric Motor Systems Market Opportunities Assessment. December 2002.

- The compressors were assumed to have a design factor of 33%. This means that the VFD compressors will typically only operate at ~75% [1/(1+33%)] of its output capacity during peak air demand periods.
- The work paper assumes that the compressors will be running at design air demand during peak electrical demand periods. Also, an Industrial compressed air systems operation is rarely dependent on seasons or weather. Thus, the measure NCP and summer CP demand savings are assumed to be the same (CF = 1.0).

Work Paper Methodology Adjustments Necessary

Cadmus found the work paper methodology and calculator to be appropriate. However, the following adjustments were necessary:

- The models of compressors used for the full load performance were updated from Ingersoll Rand (IR) to Gardener Denver as IR does not manufacture variable displacement units. Furthermore, the IR units used in the work paper analysis are particularly inefficient and no longer manufactured, thus the adjusted savings are more conservative.
- Instead of using the part-load curves from Compressed Air Challenge (CAC) for VFD case, Cadmus used the actual CAGI performance curve of the VFD because VFD technology has improved since the time that the CAC was published in 2003. The base case technologies have not changed significantly since its publishing, thus those curves are still valid.
- Cadmus updated the assumed design factor from 33% to 20% based on the engineering teams experience that manufactures rarely oversize their compressors more than 20%.

Cadmus updated hours of operation to be 4,066 per year based on the DOE's market assessment study. Whereas the work paper assumes the average hours for all industrial motors, we used the information provided in the market assessment study to determine the average operating hours of motors only associated with compressed air systems. We weighted the average by the number of applications in each motor size category as shown in Table 46.

Table 46. Weighted Average Annual Hours of Operation Calculated for Various Motor Sizes

Size Category	DOE Market Assessment Annual Hours	DEC Tracking Database Number of Applications (2013-2015)	Percentage of Total Application Population
6 - 20 hp	2,131	0	0%
21 - 50 hp	3,528	15	56%
51 - 100 hp	4,520	5	19%
101 - 200 hp	4,685	6	22%
201 - 500 hp	6,148	1	4%
501 - 1000 hp	6,156	0	0%
1000+ hp	7,485	0	0%
Weighted Average	**4,066**	**27**	**100%**

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Though each of the 27 applications in the tracking database contained self-reported operating hours, Cadmus did not use these to determine the adjusted savings for this measure. The self-reported hours varied from 74% less than to 115% greater than the adjusted hours.

Work Paper Adjustment Results

Aside from the quantity of VSDs installed as part of each application, the savings depend on the hp rating of the pump. The hp ratings are identified as *custom quantities* in DEC's tracking database. *Custom quantities* are not always recorded or recorded accurately in the DEC database. For the VSDs measure, the hp ratings were entered into the *quantity*, the *custom quantity*, or the *hp* column. This made it difficult to determine the savings for each application. Cadmus found this to be a persistent issue in the entire tracking database where the total measure savings depended on not just the quantity of the measure but also additional parameters, such as hp rating of motors or pumps. Where necessary, Cadmus calculated the actual hp values based on the incentive amounts paid to each application.

The adjusted per hp savings for each of the different base cases are shown in Table 47. The adjusted savings for VSD air compressor projects for the program years 2013 through 2015 are shown in Table 48.

The largest factor effecting the savings in the evaluated figure was better performance of the updated base case compressors and the reduction in the hours of use.

Table 47. Adjusted VSDs on Air Compressors Measure Savings

Base Case	Savings Parameter	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Variable Displacement	NCP kW	0.0450	0.0081	18%
	Summer CP kW	0.0450	0.0081	18%
	Annual kWh	188	112	60%
Load/Unload	NCP kW	0.1210	0.0624	52%
	Summer CP kW	0.1210	0.0624	52%
	Annual kWh	501	388	77%
Modulation	NCP kW	0.1510	0.0973	64%
	Summer CP kW	0.1510	0.0973	64%
	Annual kWh	629	607	96%

Table 48. Total Claimed and Adjusted Savings for VSDs on Air Compressors

Savings	Total Savings (kWh)	Total NCP Savings (kW)	Total CP Savings (kW)
Claimed [A]	1,543,273	371	371
Adjusted [B]	1,435,649	230	230
Realization Rate [B/A]	93%	62%	62%

Conclusions and Recommendations

Conclusion 1. In the case of the VSDs on air compressors measure, the savings depended on the quantity and the hp rating of air compressor motors. However, the hp rating of the motor was not always recorded or recorded accurately in the tracking database. Cadmus found this to be an issue in its review of the entire tracking database for measures whose total savings depended on not just the quantity of the measure but also additional parameters, such as hp rating of the motors.[41]

Recommendation 1. Record the quantitative parameters for measure saving determination consistently to facilitate total measure savings and program saving calculations.

Conclusion 2. The tracking database includes three measure codes for VSDs on air compressors: one with a generic base case motor control scheme, one for load/unload controls, and one for variable displacement controls. The database does not include a measure code for the modulation base case control scheme identified in the work paper.

Recommendation 2. Discontinue the generic air compressor control scheme measure code and add a measure code for the modulation base case control scheme.

41 Further discussion of this issue was provided in this report under Program Tracking Data Review and Measure Selection.

High-Efficiency Pumps

DEC applied a deemed savings per hp for each pump in the 10 applications for high-efficiency pumps. Table 49 shows the deemed savings per pumping hp for program years 2013 through 2014. The table shows deemed annual energy, NCP demand, and summer CP demand, savings included in the work paper.

Table 49. DEC Deemed Saving for High-Efficiency Pumps

Savings	Savings per hp
Average NCP Demand (kW)	0.0550
Summer CP Demand (kW)	0.0430
Energy (kWh)	201.00

Work Paper Methodology

According to the work paper, the deemed energy and demand savings per hp were calculated by averaging the energy and demand savings for 17 high-efficiency pump configurations. The configurations compared standard efficiency Bell Gossett pumps to comparable more efficient Bell Gossett pumps ranging from 2 to 20 hp. The 17 configurations had pressure heads that ranged from 20 to 100 feet and flows that ranged from 100 to 500 gallons per minute. The average loading of the pumps was assumed to be 65% based on findings in the *United States Industrial Electric Motor Systems Market Opportunities Assessment, December 2002 (MSMA).*[42] DEC used the following algorithm to calculate the energy and demand savings for each configuration.

$$\Delta kW_{NCP} = (Bhp_{Base} - Bhp_{Eff}) / \eta_{motor} \times 0.746 \text{ kW/hp}$$

$$\Delta kWh = \Delta kW_{NCP} \times H$$

$$\Delta kW_{CP} = \Delta kW_{NCP} \times CF$$

Where,

Bhp = Break hp

η_{motor} = motor efficiency, assumed, 90%

H = annual operating hours, assumed, 3,680[43] hours per year

42 U.S. Department of Energy. United States Industrial Electric Motor Systems Market Opportunities Assessment. December 2002.

43 Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

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CF = coincidence factor[44], 0.78

The work paper cites the Focus on Energy Deemed Savings Manual for annual hours of use.[45] The CF is stated to be the NYSERDA program value. The paper did not provide a source for motor efficiency.

Work Paper Methodology Adjustments Necessary

While the work paper allows DEC to assign a single energy or demand saving figure per pump hp, Cadmus found large uncertainty in the inputs and assumptions used to calculate this saving figure. There is significant variability in sizing, configuration, and operation of pumps (including the operational hours, the pressure difference through the pump, the pump flow profile, and even the fluid being pumped). One pump model may be efficient in one configuration while being very inefficient in another. Cadmus recommends this measure be included as a Custom Program measure in the future. However, for the applications submitted during the evaluation period, the following adjustments are necessary:

- The work paper methodology to normalize the savings based on a pump load factor of 65% is not correct. The source used to identify this 65% load factor was referring to the motor load factor, not the pump load factor. A pump's load factor is dependent on the specific pump output configuration and selection and Cadmus determined that the different configurations used in the 17 models were a good representation of typical pump systems. Thus, normalizing the savings to an average pump load factor is not necessary.
- The assumed motor efficiency of 90% was updated to 88.5% based on the EISA 2007 Mandatory Minimum Full-Load Efficiency Standards for motor sizes from 1-20 hp. [46]
- All of the applications included self-reported annual operating hours, which ranged from 2,130 to 8,736 hours. The hours used in the work paper are based on commercial equipment operation only. However, this measure is applicable for both commercial and industrial pumps. Thus, Cadmus determined that using the self-reported hours on each individual measure line item as appropriate for the adjustment calculations.

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44 Coincident factor is the likelihood that a piece of equipment will be running at the designed load during peak grid demand hours.

45 Kema, Inc. *Focus on Energy Evaluation Business Programs: Deemed Savings Manual V1.0.* Prepared for State of Wisconsin Public Service Commission of Wisconsin. March 22, 2010.

46 http://energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf (pg. 2-4)

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Work Paper Adjustment Results

Table 50 shows the adjusted per hp savings rates and the realization rates for the previous rates. Table 51 shows the adjusted savings figures and how they compare to the program values used in the previous years for the three ECM motor measures.

Table 50 Adjusted High-Efficiency Pumps Measure Savings

Savings	Savings per hp		
	Work Paper [A]	Adjusted [B]	Adjustment Factor [B/A]
Average NCP Demand (kW)	0.0550	0.0674	123%
Summer CP Demand (kW)	0.0430	0.0526	122%
Energy (kWh)	201.00	248.19	123%

Conclusions and Recommendations

Conclusion 1. Due to the great variability in pump sizing and configuration, Cadmus did not find an effective or accurate method to determine if an applicant's pump selection is actually an efficient choice through a Prescriptive Program.

Recommendation 1. Administer incentives for high-efficiency pumps through the Custom Program instead of the Prescriptive Program in order to accurately assess the savings potential of each application.

Table 51. Total Claimed and Adjusted Savings for High-Efficiency Pumps

Savings	Total Savings (kWh)	Total NCP Savings (kW)	Total CP Savings (kW)
Claimed [A]	121,749	33	26
Adjusted [B]	157,638	41	32
Realization Rate [B/A]	129%	123%	123%

Appendix A. Charts with Measure-Level Inputs for Duke Energy Analytics

Table 52 and Table 53 include adjusted gross and net measure savings as recommended in this evaluation:

- The tables include no savings for measure descriptions with generic base cases (when savings should be distingui Cadmus has added new measure descriptions with the associated savings distinguished by base case.
- The tables include no savings for measures where we recommend that the unit of measure be changed. Cadmus measure descriptions with the associated savings.
- The tables include no savings for measures where we recommend that the measure be moved to the Custom Pro

Table 52. Gross Savings Chart with Measure-Level Inputs

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
ECM Case Motors	Discontinue	NC					Pe
ECM Case Motors	Discontinue	SC					Pe
ECM Walk-In Cooler and Freezer Motors - ECM replacing PSC (retrofit only)	Discontinue	NC					Pe
ECM Walk-In Cooler and Freezer Motors - ECM replacing SP (retrofit only)	Discontinue	NC					Pe
ECM Case Motors replacing PSC (per hp)	New	NC/SC	9090.45	1.0640	1.0640	1.0640	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
ECM Case Motors replacing SP (per hp)	New	NC/SC	11359.25	1.3295	1.3295	1.3295	Pe
ECM Walk-In Cooler and Freezer Motors - ECM replacing PSC (per hp)	New	NC/SC	9090.45	1.0640	1.0640	1.0640	Pe
ECM Walk-In Cooler and Freezer Motors - ECM replacing SP (per hp)	New	NC/SC	11359.25	1.3295	1.3295	1.3295	Pe
Variable Frequency Drives (VFDs) - Applied to HVAC Fans Only	Continue	NC	1910.61	0.2181	0.2914	0.2990	Pe
Variable Frequency Drives (VFDs) - Applied to HVAC Fans Only	Continue	SC	1910.61	0.2181	0.2914	0.2990	Pe
Variable Frequency Drives (VFDs) - Applied to HVAC Pumps Only	Discontinue	NC					Pe
Variable Frequency Drives (VFDs) - Applied to HVAC Pumps Only	Discontinue	SC					Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
Variable Frequency Drives (VFDs) - Applied to HVAC Cooling Water Pumps	New	NC/SC	1633.12	0.1860	0.1846	0.1957	Pe
Variable Frequency Drives (VFDs) - Applied to HVAC Hot Water Pumps	New	NC/SC	1547.74	0.1770	0.0935	0.2319	Pe
Variable Frequency Drives (VFDs) - Applied to HVAC WSHP Circulation Pumps	New	NC/SC	2561.95	0.2920	0.2280	0.2949	Pe
Variable Frequency Drives (VFDs) - For Process Fluid Pumping Only	Discontinue	NC					Pe
15 Horse Power High Efficiency Pumps	Discontinue	SC					Pe
20 Horse Power High Efficiency Pumps	Discontinue	SC					Pe
3 Horse Power High Efficiency Pumps	Discontinue	SC					Pe

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Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
7.5 Horse Power High Efficiency Pumps	Discontinue	SC					Pe
High Efficiency Pumps 10 HP	Discontinue	NC					Pe
High Efficiency Pumps 15 HP	Discontinue	NC					Pe
High Efficiency Pumps 2 HP	Discontinue	NC					Pe
20 Horse Power High Efficiency Pumps	Discontinue	NC					Pe
3 Horse Power High Efficiency Pumps	Discontinue	NC					Pe
High Efficiency Pumps 5 HP	Discontinue	NC					Pe
7.5 Horse Power High Efficiency Pumps	Discontinue	NC					Pe
VSD Air Compressors	Discontinue	NC					Pe
VSD Air Compressors	Discontinue	SC					Pe
VSD Air COMP replacing modulation	New	NC/SC	607.10	0.0973	0.0973	0.0973	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
VSD Air COMP replacing load no load COMP	Continue	NC	388.20	0.0624	0.0624	0.0624	Pe
VSD Air COMP replacing variable displacement COMP	Continue	SC	111.90	0.0081	0.0081	0.0081	Pe
High Bay 2L T-5 High Output	Continue	NC	393.68	0.0878	0.0834	9,999	Pe
High Bay 4L T-5 High Output	Continue	NC	1159.16	0.2586	0.2457	9,999	Pe
High Bay 6L T-5 High Output	Continue	NC	492.10	0.1098	0.1043	9,999	Pe
High Bay 8L T-5 High Output	Continue	NC	1990.26	0.4441	0.4219	9,999	Pe
High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8)	Continue	NC	809.22	0.1806	0.1715	9,999	Pe
High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8)	Continue	NC	1263.05	0.2818	0.2677	9,999	Pe
T8 HB 4ft 8L replacing a 400-999W HID(retrofit only)	Continue	NC	852.97	0.1903	0.1808	9,999	Pe
2 High Bay 6L T-5 High Output	Continue	SC	1913.71	0.4270	0.4057	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
replacing 1000W HID							
High Bay 4L T-5 High Output	Continue	SC	1159.16	0.2586	0.2457	9,999	Pe
High Bay 6L T-5 High Output	Continue	SC	492.10	0.1098	0.1043	9,999	Pe
High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8)	Continue	SC	809.22	0.1806	0.1715	9,999	Pe
T8 HB 4ft 3L replacing 150-249W HID(retrofit only)	Continue	SC	448.35	0.1000	0.0950	9,999	Pe
High Bay T8 4ft Fluorescent 8 Lamp (F32 Watt T8)	Continue	SC	852.97	0.1903	0.1808	9,999	Pe
2 High Bay 6L T-5 High Output replacing 1000W HID	Continue	NC	1913.71	0.4270	0.4057	9,999	Pe
2 fixtures - T8 HB 4ft 8 Lamp (32W) (or single fixture 16 lamps) replacing 1,000 W HID (2 for 1 replacement retrofit only)	Continue	NC	2635.45	0.5880	0.5586	9,999	Pe
High Bay 3L T-5 High Output	Continue	NC	590.52	0.1318	0.1252	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
High Bay T8 4ft Fluorescent 3 Lamp (F32 Watt T8)	Continue	NC	448.35	0.1000	0.0950	9,999	Pe
High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8)	Continue	SC	1263.05	0.2818	0.2677	9,999	Pe
T8 HB 4ft 2L rplcng 150-249W HID (retrofit only)	Continue	NC	620.59	0.1385	0.1315	9,999	Pe
High Performance Low Watt T8 4ft 1 lamp, replacing standard T8	Continue	SC	42.91	0.0097	0.0073	9,999	Pe
High Performance Low Watt T8 4ft 2 lamp, replacing standard T8	Continue	SC	70.87	0.0160	0.0121	9,999	Pe
High Performance Low Watt T8 4ft 3 lamp, replacing standard T8	Continue	SC	91.93	0.0207	0.0157	9,999	Pe
High Performance Low Watt T8 4ft 4 lamp, replacing standard T8	Continue	SC	135.52	0.0305	0.0232	9,999	Pe
High Performance T8 4ft 2 lamp	Continue	SC	85.58	0.0193	0.0146	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
fixture replacing T12 4ft 2 lamp							
High Performance T8 4ft 2 lamp, replacing T12 High Output 8ft 1 lamp	Continue	SC	180.48	0.0406	0.0309	9,999	Pe
High Performance T8 4ft 4 lamp, replacing T12 High Output 8ft 2 lamp	Continue	SC	330.72	0.0744	0.0566	9,999	Pe
High Performance T8 4ft 1 lamp, replacing standard T8	Continue	SC	28.46	0.0064	0.0049	9,999	Pe
High Performance T8 4ft 1 lamp, replacing T12-HPT8	Continue	SC	63.69	0.0143	0.0109	9,999	Pe
High Performance T8 4ft 2 lamp, replacing standard T8	Continue	SC	44.93	0.0101	0.0077	9,999	Pe
High Performance T8 4ft 3 lamp, replacing standard T8	Continue	SC	51.23	0.0115	0.0088	9,999	Pe
High Performance T8 4ft 3 lamp, replacing T12-HPT8	Continue	SC	143.38	0.0323	0.0245	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
High Performance T8 4ft 4 lamp, replacing standard T8	Continue	SC	76.43	0.0172	0.0131	9,999	Pe
Low Watt T8 lamps 2-4ft, replacing standard 32 Watt T8	Continue	SC	21.68	0.0049	0.0037	9,999	Pe
High Performance Low Watt T8 4ft 1 lamp, replacing standard T8	Continue	NC	42.91	0.0097	0.0073	9,999	Pe
High Performance Low Watt T8 4ft 2 lamp, replacing standard T8	Continue	NC	70.87	0.0160	0.0121	9,999	Pe
High Performance Low Watt T8 4ft 3 lamp, replacing standard T8	Continue	NC	91.93	0.0207	0.0157	9,999	Pe
High Performance T8 4ft 2 lamp fixture replacing T12 4ft 2 lamp	Continue	NC	85.58	0.0193	0.0146	9,999	Pe
Relamp T8 4ft 32W fixtures with Reduced Wattage	Continue	NC	21.68	0.0049	0.0037	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
T8 lamps 28 watts or less							
High Performance T8 4ft 4 lamp, replacing T12-HPT8	Continue	NC	163.16	0.0367	0.0279	9,999	Pe
High Performance T8 4ft 1 lamp, replacing standard T8	Continue	NC	28.46	0.0064	0.0049	9,999	Pe
High Performance T8 4ft 1 lamp fixture replacing T12 4ft 1 lamp	Continue	NC	63.69	0.0143	0.0109	9,999	Pe
High Performance T8 4ft 2 lamp, replacing standard T8	Continue	NC	44.93	0.0101	0.0077	9,999	Pe
High Performance T8 4ft 3 lamp, replacing standard T8	Continue	NC	51.23	0.0115	0.0088	9,999	Pe
High Performance T8 4ft 3 lamp, replacing T12-HPT8	Continue	NC	143.38	0.0323	0.0245	9,999	Pe
High Performance T8 4ft 4 lamp,	Continue	NC	76.43	0.0172	0.0131	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	
replacing standard T8							
High Performance Low Watt T8 4ft 4 lamp, replacing standard T8	Continue	NC	135.52	0.0305	0.0232	9,999	Pe
High Performance T8 4ft 2 lamp, replacing T12 High Output 8ft 1 lamp	Continue	NC	180.48	0.0406	0.0309	9,999	Pe
High Performance T8 4ft 4 lamp, replacing T12 High Output 8ft 2 lamp	Continue	NC	330.72	0.0744	0.0566	9,999	Pe
Reduced Wattage T8 4ft 1 lamp of 28W or less & ballast replacing standard T12 4ft 1 lamp	Continue	NC	78.14	0.0176	0.0134	9,999	Pe
Reduced Wattage T8 4ft 1 lamp of 28W or less & ballast replacing standard T12 4ft 1 lamp	Continue	SC	78.14	0.0176	0.0134	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
Reduced Wattage T8 4ft 2 lamp of 28 W or less & ballast replacing standard T12 4 ft 2 lamp	Continue	NC	111.52	0.0251	0.0191	9,999	Pe
Reduced Wattage T8 4ft 2 lamp of 28 W or less & ballast replacing standard T12 4 ft 2 lamp	Continue	SC	111.52	0.0251	0.0191	9,999	Pe
Reduced Wattage T8 4ft 3 lamp of 28 W or less & ballast replacing standard T12 4 ft 3 lamp	Continue	NC	184.08	0.0414	0.0315	9,999	Pe
Reduced Wattage T8 4ft 3 lamp of 28 W or less & ballast replacing standard T12 4 ft 3 lamp	Continue	SC	184.08	0.0414	0.0315	9,999	Pe
Reduced Wattage T8 4ft 4 lamp of 28 W or less & ballast replacing standard T12 4 ft 4 lamp	Continue	NC	222.25	0.0500	0.0380	9,999	Pe
Reduced Wattage T8 4ft 4 lamp of 28 W or less & ballast	Continue	SC	222.25	0.0500	0.0380	9,999	Pe

Measure Name	Evaluation Recommendation	State	EM&V Gross Target Annual kWh Savings/Unit	EM&V Gross Target Annual Non-Coincident kW/Unit	EM&V Gross Target Annual Summer Coincident kW/Unit	EM&V Gross Target Annual Winter Coincident kW/Unit	I
replacing standard T12 4 ft 4 lamp							
Replace 60-100W incandescent with ENERGY STAR qualified LED downlight 18 Watts or less. (retrofit only)	Continue	NC	234.05	0.0647	0.0498	9,999	Pe
Replace 60-100W incandescent with ENERGY STAR qualified LED downlight 18 Watts or less. (retrofit only)	Continue	SC	234.05	0.0647	0.0498	9,999	Pe
Replace incandescent bulbs with Energy Star LED (retrofit only)	Continue	NC	140.76	0.0378	0.0291	9,999	Pe
Replace incandescent bulbs with Energy Star LED (retrofit only)	Continue	SC	140.76	0.0378	0.0291	9,999	Pe

Table 53. Net Savings Chart with Measure-Level Inputs and Recommendations

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
ECM Case Motors	Discontinue					3
ECM Case Motors	Discontinue					3
ECM Walk-In Cooler and Freezer Motors - ECM replacing PSC (retrofit only)	Discontinue					3

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
ECM Walk-In Cooler and Freezer Motors - ECM replacing SP (retrofit only)	Discontinue					3
ECM Case Motors replacing PSC (per hp)	New	3636.18	0.4256	0.4256	9,999	
ECM Case Motors replacing SP (per hp)	New	4543.70	0.5318	0.5318	9,999	
ECM Walk-In Cooler and Freezer Motors - ECM replacing PSC (per hp)	New	3636.18	0.4256	0.4256	9,999	
ECM Walk-In Cooler and Freezer Motors - ECM replacing SP (per hp)	New	4543.70	0.5318	0.5318	9,999	
Variable Frequency	Continue	764.25	0.0872	0.1165	0.1196	3

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
Drives (VFDs) - Applied to HVAC Fans Only						
Variable Frequency Drives (VFDs) - Applied to HVAC Fans Only	Continue	764.25	0.0872	0.1165	0.1196	3
Variable Frequency Drives (VFDs) - Applied to HVAC Pumps Only	Discontinue					3
Variable Frequency Drives (VFDs) - Applied to HVAC Pumps Only	Discontinue					3
Variable Frequency Drives (VFDs) - Applied to HVAC Cooling Water Pumps	New	653.25	0.0744	0.0739	0.0783	
Variable Frequency Drives (VFDs) - Applied to HVAC	New	619.09	0.0708	0.0374	0.0928	

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
Hot Water Pumps						
Variable Frequency Drives (VFDs) - Applied to HVAC WSHP Circulation Pumps	New	1024.78	0.1168	0.0912	0.1179	
Variable Frequency Drives (VFDs) - For Process Fluid Pumping Only	Discontinue					3
15 Horse Power High Efficiency Pumps	Discontinue					1
20 Horse Power High Efficiency Pumps	Discontinue					1
3 Horse Power High Efficiency Pumps	Discontinue					1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
7.5 Horse Power High Efficiency Pumps	Discontinue					1
High Efficiency Pumps 10 HP	Discontinue					1
High Efficiency Pumps 15 HP	Discontinue					1
High Efficiency Pumps 2 HP	Discontinue					1
20 Horse Power High Efficiency Pumps	Discontinue					1
3 Horse Power High Efficiency Pumps	Discontinue					1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
High Efficiency Pumps 5 HP	Discontinue					1
7.5 Horse Power High Efficiency Pumps	Discontinue					1
VSD Air Compressors	Discontinue					3
VSD Air Compressors	Discontinue					3
VSD Air COMP replacing modulation	New	242.84	0.0389	0.0389	9,999	
VSD Air COMP replacing load no load COMP	Continue	155.28	0.0250	0.0250	9,999	6

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
VSD Air COMP replacing variable displacement COMP	Continue	44.76	0.0032	0.0032	9,999	6
High Bay 2L T-5 High Output	Continue	338.56	0.0755	0.0718	9,999	1
High Bay 4L T-5 High Output	Continue	996.88	0.2224	0.2113	9,999	1
High Bay 6L T-5 High Output	Continue	423.20	0.0944	0.0897	9,999	1
High Bay 8L T-5 High Output	Continue	1711.62	0.3819	0.3628	9,999	1
High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8)	Continue	695.93	0.1553	0.1475	9,999	1
High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8)	Continue	1086.22	0.2424	0.2302	9,999	1
T8 HB 4ft 8L replacing a 400-999W HID(retrofit only)	Continue	733.55	0.1637	0.1555	9,999	1
2 High Bay 6L T-5 High Output	Continue	1645.79	0.3672	0.3489	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
replacing 1000W HID						
High Bay 4L T-5 High Output	Continue	996.88	0.2224	0.2113	9,999	1
High Bay 6L T-5 High Output	Continue	423.20	0.0944	0.0897	9,999	1
High Bay T8 4ft Fluorescent 4 Lamp (F32 Watt T8)	Continue	695.93	0.1553	0.1475	9,999	1
T8 HB 4ft 3L replacing 150-249W HID(retrofit only)	Continue	385.58	0.0860	0.0817	9,999	1
High Bay T8 4ft Fluorescent 8 Lamp (F32 Watt T8)	Continue	733.55	0.1637	0.1555	9,999	1
2 High Bay 6L T-5 High Output replacing 1000W HID	Continue	1645.79	0.3672	0.3489	9,999	1
2 fixtures - T8 HB 4ft 8 Lamp (32W) (or single fixture 16 lamps) replacing 1,000	Continue	2266.49	0.5057	0.4804	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
W HID (2 for 1 replacement retrofit only)						
High Bay 3L T-5 High Output	Continue	507.84	0.1133	0.1076	9,999	1
High Bay T8 4ft Fluorescent 3 Lamp (F32 Watt T8)	Continue	385.58	0.0860	0.0817	9,999	1
High Bay T8 4ft Fluorescent 6 Lamp (F32 Watt T8)	Continue	1086.22	0.2424	0.2302	9,999	1
T8 HB 4ft 2L rplcng 150-249W HID (retrofit only)	Continue	533.71	0.1191	0.1131	9,999	6
High Performance Low Watt T8 4ft 1 lamp, replacing standard T8	Continue	36.90	0.0083	0.0063	9,999	1
High Performance Low Watt T8 4ft 2 lamp,	Continue	60.94	0.0137	0.0104	9,999	1

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Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
replacing standard T8						
High Performance Low Watt T8 4ft 3 lamp, replacing standard T8	Continue	79.06	0.0178	0.0135	9,999	1
High Performance Low Watt T8 4ft 4 lamp, replacing standard T8	Continue	116.55	0.0262	0.0199	9,999	1
High Performance T8 4ft 2 lamp fixture replacing T12 4ft 2 lamp	Continue	73.60	0.0166	0.0126	9,999	1
High Performance T8 4ft 2 lamp, replacing T12 High Output 8ft 1 lamp	Continue	155.22	0.0349	0.0266	9,999	1
High Performance T8 4ft 4 lamp,	Continue	284.42	0.0640	0.0487	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
replacing T12 High Output 8ft 2 lamp						
High Performance T8 4ft 1 lamp, replacing standard T8	Continue	24.47	0.0055	0.0042	9,999	1
High Performance T8 4ft 1 lamp, replacing T12-HPT8	Continue	54.77	0.0123	0.0094	9,999	1
High Performance T8 4ft 2 lamp, replacing standard T8	Continue	38.64	0.0087	0.0066	9,999	1
High Performance T8 4ft 3 lamp, replacing standard T8	Continue	44.06	0.0099	0.0075	9,999	1
High Performance T8 4ft 3 lamp, replacing T12-HPT8	Continue	123.30	0.0278	0.0211	9,999	1

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Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
High Performance T8 4ft 4 lamp, replacing standard T8	Continue	65.73	0.0148	0.0112	9,999	1
Low Watt T8 lamps 2-4ft, replacing standard 32 Watt T8	Continue	18.65	0.0042	0.0032	9,999	1
High Performance Low Watt T8 4ft 1 lamp, replacing standard T8	Continue	36.90	0.0083	0.0063	9,999	1
High Performance Low Watt T8 4ft 2 lamp, replacing standard T8	Continue	60.94	0.0137	0.0104	9,999	1
High Performance Low Watt T8 4ft 3 lamp, replacing standard T8	Continue	79.06	0.0178	0.0135	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
High Performance T8 4ft 2 lamp fixture replacing T12 4ft 2 lamp	Continue	73.60	0.0166	0.0126	9,999	1
Relamp T8 4ft 32W fixtures with Reduced Wattage T8 lamps 28 watts or less	Continue	18.65	0.0042	0.0032	9,999	1
High Performance T8 4ft 4 lamp, replacing T12-HPT8	Continue	140.32	0.0316	0.0240	9,999	1
High Performance T8 4ft 1 lamp, replacing standard T8	Continue	24.47	0.0055	0.0042	9,999	1
High Performance T8 4ft 1 lamp fixture replacing T12 4ft 1 lamp	Continue	54.77	0.0123	0.0094	9,999	1
High Performance T8	Continue	38.64	0.0087	0.0066	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
4ft 2 lamp, replacing standard T8						
High Performance T8 4ft 3 lamp, replacing standard T8	Continue	44.06	0.0099	0.0075	9,999	1
High Performance T8 4ft 3 lamp, replacing T12-HPT8	Continue	123.30	0.0278	0.0211	9,999	1
High Performance T8 4ft 4 lamp, replacing standard T8	Continue	65.73	0.0148	0.0112	9,999	1
High Performance Low Watt T8 4ft 4 lamp, replacing standard T8	Continue	116.55	0.0262	0.0199	9,999	1
High Performance T8 4ft 2 lamp, replacing T12	Continue	155.22	0.0349	0.0266	9,999	1

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
High Output 8ft 1 lamp						
High Performance T8 4ft 4 lamp, replacing T12 High Output 8ft 2 lamp	Continue	284.42	0.0640	0.0487	9,999	1
Reduced Wattage T8 4ft 1 lamp of 28W or less & ballast replacing standard T12 4ft 1 lamp	Continue	67.20	0.0151	0.0115	9,999	3
Reduced Wattage T8 4ft 1 lamp of 28W or less & ballast replacing standard T12 4ft 1 lamp	Continue	67.20	0.0151	0.0115	9,999	3
Reduced Wattage T8 4ft 2 lamp of 28 W or less & ballast replacing	Continue	95.91	0.0216	0.0164	9,999	3

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
standard T12 4 ft 2 lamp						
Reduced Wattage T8 4ft 2 lamp of 28 W or less & ballast replacing standard T12 4 ft 2 lamp	Continue	95.91	0.0216	0.0164	9,999	3
Reduced Wattage T8 4ft 3 lamp of 28 W or less & ballast replacing standard T12 4 ft 3 lamp	Continue	158.30	0.0356	0.0271	9,999	3
Reduced Wattage T8 4ft 3 lamp of 28 W or less & ballast replacing standard T12 4 ft 3 lamp	Continue	158.30	0.0356	0.0271	9,999	3
Reduced Wattage T8 4ft 4 lamp of 28 W or less & ballast	Continue	191.13	0.0430	0.0327	9,999	3

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
replacing standard T12 4 ft 4 lamp						
Reduced Wattage T8 4ft 4 lamp of 28 W or less & ballast replacing standard T12 4 ft 4 lamp	Continue	191.13	0.0430	0.0327	9,999	3
Replace 60-100W incandescent with ENERGY STAR qualified LED downlight 18 Watts or less. (retrofit only)	Continue	201.28	0.0556	0.0428	9,999	3
Replace 60-100W incandescent with ENERGY STAR qualified LED downlight 18 Watts or less. (retrofit only)	Continue	201.28	0.0556	0.0428	9,999	3
Replace incandescent	Continue	121.05	0.0325	0.0250	9,999	3

Measure Name	Evaluation Recommendation	EM&V Net Target Annual kWh Savings/Unit	EM&V Net Target Annual Non-Coincident kW/Unit	EM&V Net Target Annual Summer Coincident kW/Unit	EM&V Net Target Annual Winter Coincident kW/unit	SRC_PGM_MEAS
bulbs with Energy Star LED (retrofit only)						
Replace incandescent bulbs with Energy Star LED (retrofit only)	Continue	121.05	0.0325	0.0250	9,999	3

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Appendix B. Summary Form

DUKE ENERGY

Smart $aver Nonresidential Prescriptive Incentive Program

Duke Energy Carolinas
Completed EM&V Fact Sheet
2016 Evaluation – Cadmus

Program Description

The Duke Energy Smart $aver Nonresidential Prescriptive Incentive Program encourages energy efficiency by providing incentives for qualifying high-efficiency measures such as lighting, HVAC, and motors. Duke Energy business customers may install the energy-efficient measures and then apply for the incentive within 90 days of installing the equipment and provide proof of purchase.

Date	August 4, 2017
Region(s)	Carolinas
Evaluation Period	Applications Paid from January 2013 through July 2015
Gross Energy Savings (kWh)	Adjusted savings calculated for select measures
Net Coincident kW Impact (Summer)	Adjusted savings calculated for select measures
Measure life	Various
Net Energy Savings (kWh)	Adjusted savings calculated for select measures
Process Evaluation	Yes, reported separately.
Previous Evaluation(s)	Yes.

Evaluation Methodology

The evaluation team performed engineering desk reviews on the work papers describing deemed energy and demand saving calculation methodologies for the following measures: ECM motors, high efficiency pumps, high efficiency linear fluorescents, high-bay linear fluorescents, LEDs, VFDs on motors, and VSDs on air compressors.

The evaluation team adjusted the claimed per-unit energy and demand saving estimates, as necessary, and applied the updated values to all measure participants. The evaluation team calculated a lighting and non-lighting Net-to-Gross (NTG) ratio and calculated net energy and demand saving estimates for the measures reviewed.

Impact Evaluation Details:

- The majority of the claimed program savings are attributed to lighting and HVAC measures. The pumps measure category contributed the least to the overall claimed program savings.
- The desk review analysis for the ten measures sampled produced realization rates ranging from 68% to 139%.
- The evaluation team calculated 40% NTG ratio for lighting and 86% NTG ratio for non-lighting projects.